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ROCKS and MINERALS

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Courtesy Commonwealth Immigration Office.
Opal Mines, White Cliffs, New South Wales.

Special Opal Number

Granite and Gold Win National Honors

A NON-TECHNICAL MAGAZINE
—ON—
MINING - PROSPECTING - GEOLOGY - MINERALOGY

THE BULLETIN BOARD

Granite and Gold Win

Sweeping Victories are Gained over Marble and Quartz Their Nearest Rivals

The great contest is over. And for the first time in the history of the country the people of the United States have selected a rock and a mineral which in their minds most truly typify or symbolize America as being characteristic of American mountains and American soil. The specimens so honored are granite, a rock, and gold, a mineral.

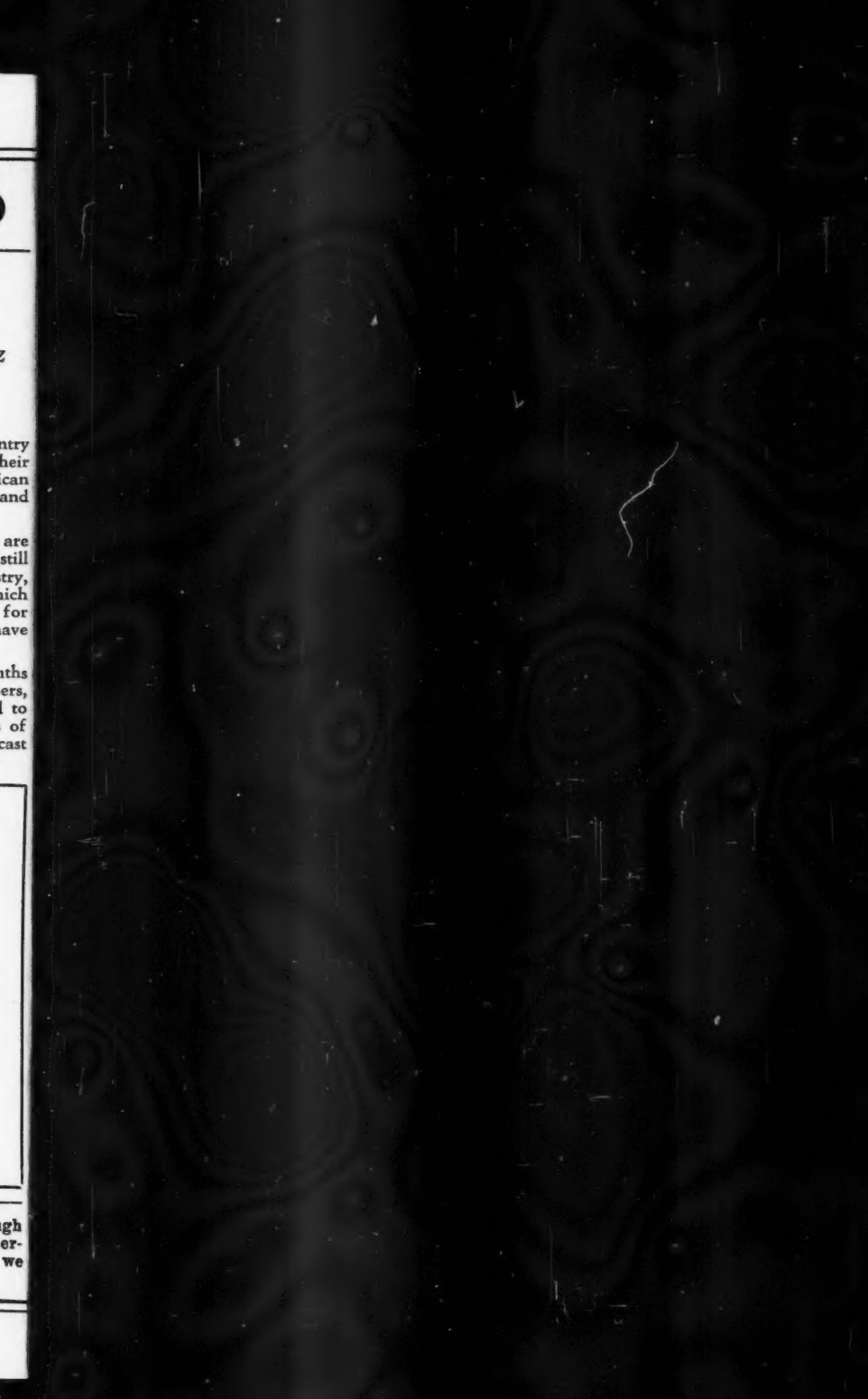
We believe the people have made a very wise choice. For granite and gold are found in practically every state in the Union and they have played and are still playing a very vital part in the progress and development of the nation in industry, commerce and the arts. Aside from usefulness, they also possess qualities which make them admirable to serve as National Specimens—strength and durability for the granite and nobleness, purity and beauty for the gold. Truly the people have voted wisely.

The contest, sponsored by ROCKS AND MINERALS, which spread over sixteen months and ended Dec. 31, 1932, aroused considerable interest and discussion. Newspapers, magazines, schools and colleges, clubs and individuals in general cooperated and to whom our grateful thanks are extended. It was during the closing two months of the contest, however, that balloting became unusually heavy when the number cast for this period almost doubled the total number previously cast.

HOW THE CONTEST ENDED DEC. 31, 1932

ROCKS		MINERALS	
Granite	33,271	Gold	45,003
Marble	20,612	Quartz	13,698
Coal	6,541	Garnet	4,892
Serpentine	5,875	Hematite	3,123
Limestone	2,657	Mica	1,902
Sandstone	1,280	Galena	1,291
Gneiss	973	Pyrite	1,100
Conglomerate	946	Chalcopyrite	681
Slate	551	Calcite	671
Schist	433	Limonite	351
Shale	380	Sphalerite	219
Miscellaneous	104	Miscellaneous	692
Total votes cast	73,623	Total votes cast	73,623

WANTED: Correspondents in all parts of the world who will be kind enough to send us notes and news items on minerals, etc., that they think may be interesting to the subscribers of ROCKS AND MINERALS. Such as are available we shall be very glad to print in the magazine.



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ROCKS and MINERALS

A NON-TECHNICAL MAGAZINE
—ON—
MINING—PROSPECTING—GEOLOGY—MINERALOGY

Published Quarterly

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ROCKS AND MINERALS PEEKSKILL, N. Y., U. S. A.

The Official Journal of the Rocks and Minerals Association

Linnaeite, a Sulphide of Cobalt

Tradition tells us that Mine La Motte, in Madison County, Missouri, was first worked by the Spaniards, later by the French, and then by our own countrymen. Today this area, covering, perhaps, three by five miles, has little to offer collectors, though once in a while, a stronger back or a more persistent seeker will uncover a few good specimens. We have been fortunate in obtaining about fifty very fine specimens of Linnaeite, var. Siegenite—that is, containing Nickel—from this historic locality. The Linnaeite occurs both massive and in crystals in a Quartz sandstone. It has a pinkish-silver color, many specimens showing the green of nickel salts. While these specimens are not of spectacular appearance, their interest lies in the fact that they came from a historic locality which, with one unimportant exception, is the only occurrence of Linnaeite in the United States. We recommend these specimens highly.

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ROCKS and MINERALS
Edited and Published by Peter Zodac

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MARCH 1933

The Story of Opal

—*By*—

G. FREDERICK SHEPHERD

Technical Assistant in Geology, Museum of Science and Industry, Chicago, Illinois

Opal An Evil Omen?

It is most deplorable that the mind of the public should be so shallow and whimsical that it would permit the magnificent and ever-changing beauty of the opal to be maligned with puny superstition. Many objects of real worth have thus lost part of their value because of some misunderstanding, ungrounded report, or superstition, and the opal is one of them—with little, if any, reason for the spread of its ill-fated powers.

The opal has not always been thought of as being unlucky, and it is encouraging to note that the cloud of fate is slowly lifting from the opal and to say that it is gradually recovering from the effects of a rumor that has so seriously impaired its sale. It is possible that the discovery of the Australian fields, about a half-century ago, has helped to bring the opal into favor again.

Many examples of its favor or disfavor can be cited. While the Empress Eugenie of France refused to wear opals because it was considered as tempting bad luck to do so, Queen Victoria, on the other hand, looked upon opals in the light of the sentiments that have been attached to them: hope, innocence, and purity, and she gave jewelry set with opals to each of her daughters on their marriage. The Queen must be credited with doing much to bring the opal into favor by her fondness of the gem. The Empress Augusta was once presented with a parure of opals from New South Wales by Emperor William of Germany; and the Duchess of Marlborough is said to have cherished among her fondest possessions a fine Australian opal.

That opals were much in favor in the days of Pliny we can be assured from his description and account of the "Opal of Nonius". Evidence of its favor in the Sixteenth Century is found in the story of Cardano. He said that he bought an opal for fifteen gold crowns and was as happy with it as he was with a diamond for which he paid five hundred crowns. Emphasis is added to the strength of this evidence when one considers the fact that

superstitions were quite common in those days and yet none were associated with the opal, which, being a source of pleasure to Cardano, added to his good fortune. It remained for the Nineteenth Century to originate the unreasonable and inexplicable superstitions that caused the opal to suffer under a shroud of ill luck.

In the first place, we must distinguish between the reputation of bringing bad luck and the superstition regarding the opal. There seems to be some reason for the opal being symbolic of bad luck, for, due to its fragility, it cracks and chips with ease. When craftsmen undertake the responsibility of cutting or setting opal, they become obligated to pay the owner for any damage which might come to the stone while they are working with it. It very frequently happens, through no fault of their own, that the opals crack and break while being handled. Consequently it is easy to understand that such craftsmen would soon come to consider the opal as bringing bad luck. A Chicago jeweler has told me that many jewelers absolutely forbid any opals being taken into their shops. They consider it too much of a risk to handle them.

And so we see that the ill luck reputation is based on actual conditions, but the real superstition of the opal seems to have a cause which appeals more to the mind's fancy than does a cold laboratory experience. Sir Walter Scott is thought to have initiated the superstition of the opal, because previous to 1829 opals were a favorite in Europe and America, but twelve months later the value of opal in European markets depreciated over fifty per cent. All this seems to have been due to a misinterpretation of **Anne of Geierstein,** published that year.

Scott tells of an enchanted princess, Lady Hermione, who always wore a brilliant opal in her hair. It, too, was a product of enchantment and was credited with having shown with dazzling light when she was happy, sent out red fire when she was angry, and then when a few drops of holy water touched it, it faded immediately into a dull, colorless stone. The Princess swooned and the next day only ashes remained where her body had been carried. How foolish it is to claim that the opal was responsible for this calamity! Scott might as easily have chosen another gem for his novel, in so far as its fated powers are concerned, but he probably selected the opal because of its great play of various colors, and because it is hydroscopic. So, Kunz says "we are perfectly justified in returning to the older belief of the manifold virtues of the opal, only remembering that this gem is a little more fragile than many others and should be more carefully handled and guarded."

There is still another legend regarding the opal that pertains to beliefs concerning it. The opal was for a long time supposed to have been connected with the eye. In medieval times, the opal was called **ophthalmus lapis** because of the reputation of its ability to cure diseases of the eye and also to make its wearer invisible. Because of the later, it was called the "patron of thieves". In Queen Elizabeth's time, because of the same derivation, it was thought to be connected in some way with the Evil Eye. Nevertheless, this was false as the derivation was considered by earlier writers to be due to its beneficial effect upon the sight. So we see, in our glance upon the history of the opal, a mingled tradition of good and evil.

Dr. Kunz tells another story about the opal which I would like to relate before passing. The ability of the opal to render its wearer invisible has some bearing on the legend of Gyges. Gyges was a shepherd in the service of the Lydian King. During a violent storm, one day, an earthquake opened up a great chasm near where the shepherd was feeding his flock. He was curious to investigate this and when he descended into the hollow, he saw a great brazen horse with openings at the sides. In the horse he saw a large man with a golden ring glittering on one of his fingers. He removed this ring and took his departure.

A few days later, the shepherds gathered to prepare their monthly reports to the king. As Gyges sat among them he carelessly turned the ring he was wearing so that the stone faced the palm of his hand. He immediately became invisible and heard the other shepherds talking of him as though he were absent. He repeated the experiment to make sure that this was true and then, realizing the great possibilities open to him, he asked permission to take the reports to the king. This favor was granted and gaining entrance to the palace he soon found

means to seduce the queen who aided him in slaying the king whereby he gained possession to the kingdom.

Why Is An Opal a Gem?

But let us lay aside the hypothetical and illusionary qualities of the opal and observe the facts of the stone to see what it is, how it originated, where it comes from, and what properties it has, that it should be valued as a gem.

To some, the formation of a gem stone by nature is called accidental, or perchance miraculous. Why, they might argue, should nature be able to combine certain chemical elements and endow them with such physical properties, that when found, cut and polished by a human being, they should result in a stone so beautiful and valuable?

But the ways of nature are not always so strange. She does not work without reason and plan. Things may "just happen" and a gem be formed, but on the other hand, we know that some things do happen in an understandable way. True, the same chemical elements may combine, and have nearly the same physical properties, and still no gem result, and perhaps it is because this is the usual thing that happens that makes the extraordinary occurrence produce a gem with assigned value. What does happen to make an opal?

Opal Properties

Let us look over some of the physical characteristics of the opal, a detailed account of which may be found in any of the text-books of Mineralogy listed in the Bibliography. Opal may be considered as a hardened jelly of silica and water. Without the water, the composition would be the same as quartz. The moisture content may vary from 1 to 21 per cent., but it is usually from 3 to 13 per cent. The importance of the water is the relationship it bears to the opalescent qualities, as has been interpreted by some, and to the refringent character as discussed below. Many impurities have been found in opal, such as ferric oxide, alumina, lime, magnesia, and the alkalies; when present they usually account for many of the varieties. Opal is soluble in KF and KOH.

Inasmuch as so many varieties of opal exist, about as many physical features may be listed as there are varieties. The structure of the opal, for instance, is amorphous, and it may occur either in massive, reniform, botryoidal, stalatitic, tuberose, or earthy forms, depending on the variety described. It does not crystallize in any regular form as do most gem stones.

As to color, one might name any one or all the colors and still be describing some opal. It may be colorless or of any shade or tint or combination of red, yellow, green, blue, or black. As the colors pertain directly to the varieties, the reader is referred to the "Opal Glossary" in this Issue. The streak of all varieties is white.

As mentioned earlier in this article, the opal is not hard, as gems go. On Moh's scale, the hardness varies from 5.5 to 6.5, but in earthy varieties it may be as low as 1. Thus some specimens may scratch a knife blade (5.5) and others can easily be scratched by feldspar (6) or quartz (7). Opal may break with a conchoidal fracture in some varieties, while in others the fracture may be irregular or earthy. The specific gravity ranges from 1.9 to 2.3, but when pure is 2.1 - 2.2.

The diaphaneitic qualities vary greatly as one can readily see by glancing over the descriptions of the varities. Opal may be transparent or opaque, or at any degree of transparency or translucency between the two extremes. The luster, too, varies considerably. It may be vitreous, subvitreous, resinous, pearly, or earthy.

For those interested in its petrographic qualities, opal is isotropic, but at times may show polarization due to internal strain. When displaying the later, globules show a black cross of negative character like colloidal substances. The refringence of the opal depends on the water content. Thus specimens with very little water have an index of refraction of 1.406 and those containing much water 1.46. In thin sections opal is colorless. Like quartz, it has a high melting point.

Origin Of The Play Of Color In Opal

I will not discuss here the varieties of opal as they have been considered in detail in the Glossary. It suffices to say that there are two great classes of opal: the Common and Precious. The chief distinction between the two is the great

play of color exhibited in the Precious Opals. Inasmuch as this greatly aids in determining the value of the gem, let us look into the causes of this opalescence.

This has been the subject of much controversy and has been written of by many. A study of nearly a dozen of these reveals several explanations for the phenomenon. As some opaque opals may be made to show color and opalescence for a short time after immersion in water, the phenomenon is said by some to be due to an uneven distribution of the water content. This property is sometimes taken advantage of to sell worthless opals to tourists and other transient buyers.

Another writer claims that the play of color in gem material is due to the interference of light-rays reflected from the sides of thin layers of opal material with different densities. Most writers agree that the opalescent phenomenon is not due to chemical composition nor to the presence of any mineral pigment, but rather to the influence of slight differences of physical structure.

Sir David Brewster has investigated the origin of the play of color and has ascribed it to the presence of microscopic cavities in the stone. Still other claims have been made—that the stone is internally a mass of fissures and cracks upon which reflection and decomposition of light takes place. The optical effect produced in any case is much the same as that of sunshine on a soap bubble.

But I think the question has been satisfactorily answered by Behrends who probably has given more study to this subject than has anyone else. He has written a learned monograph on the cause of opalescence published by the Royal Academy of Science in Vienna. He contends that the play of color is due to thin curved scales or lamellae of opal, the refractive power of which may differ by 0.1 from that of the surrounding mass. These thin lamellae are thought by Behrends to have been originally formed in parallel positions, but have been changed, bent, and finally cracked and broken during the solidification of the opal. As Prior has expressed it "It is a curious paradox in Nature that this gem owes its extreme beauty to a mass of imperfections."

In review, let us note that the distinguishing characteristics of the opal are its great play of color, its low specific gravity, its relative softness, its monorefringent character, its colloidal structure, and its solubility in alkalies and hydrofluoric acid. It remains to examine the geological and geographical occurrence of the opal.

Geographical and Geological Distribution of Opal

It may appear from the following description of localities in which opal is found that it is ubiquitous, but such is not the case. Its relatives—silicified wood, diatomaceous earth, et cetera—are very common, but the precious opal is by no means of frequent occurrence.

Australia

Not only is Australia the greatest producer of opal, but it is also the producer of the most beautiful stones. This fact has had a double effect in that Australia has almost entirely supplanted Hungary as a source for opal, and also in that it has gone a long way toward restoring the opal to popularity after the disastrous effects of the superstition prevalent in the Nineteenth Century.

There is a small production of opal from Victoria in South Australia, but the large and important fields are located in Queensland and New South Wales. Up to the end of 1899, £116,000 worth of opals were produced in Queensland and £376,000 worth in New South Wales.

Queensland opals were first discovered at Listowel Downs in 1872, and were first actively produced in 1878, when the Aladdin mine, which was a portion of a freehold grant of land made by Mr. Bond for the purpose of developing the trade, was floated into a company. Previously, however, the Honorable John Weber of Kyabra Station had taken a great interest in this same matter.

There are two geological occurrences of opal in Queensland; the first in the sedimentary beds of the Upper Cretaceous age, known as the Desert Sandstone formation, and the second in a vesicular basalt of post-Cretaceous age. The first occurrence is unique to Queensland and New South Wales, but the latter occurrence is similar to that in Czechoslovakia and Mexico.

The Desert Sandstone covers an area approximately three quarters of the total extent of Queensland. It lies horizon-

tally and unconformably on the Rolling Downs formation of the Lower Cretaceous age. This latter consists of a series of sandstones, shales, and other sedimentary rocks, and according to Mr. Jack, after the Rolling Down formation had been deposited in a comparatively narrow sea, which connected the gulf of Carpentaria with the great Australian Bight, a great upheaval took place and the denudation of the Rolling Downs formation followed for a considerable time. Unequal disatrophic movements then brought about lacustrine conditions on portions of the now uplifted bottom of the old sea and in other portions it permitted the admission of ocean waters resulting in the deposit of the Desert Sandstone formation. Finally a general upheaval placed the deposits of this period approximately in the position in which we now find them. While we have abundant evidence that the Upper Cretaceous rock formerly covered nearly all of the Rolling Down formation, it has now been removed by erosion so that it occupies less than one-twentieth part of the original area. The present portions of the Desert Sandstone are now found in low ranges, table lands, and isolated flat-top hills. Small detached patches are found as outliers. These beds have a thickness of one hundred to two hundred feet, although seldom over one hundred and sixty feet.

Precious opal deposits are found wholly in these outlying patches. Stratigraphically there are two well-marked divisions consisting of soft sandstones and clays overlying extremely hard siliceous rocks, and the precious opal occurs almost entirely in the softer beds underlying the siliceous capping, although in one or two instances the opal has been found in the porcellanite immediately overlying them. There is a tendency to opalization everywhere in the Desert Sandstone resulting most frequently in the common forms with the precious varieties found only occasionally in small patches.

The opal in the igneous rocks occurs filling cavities and fissures or seams where it has probably resulted from the action of magmatic waters upon the silicates of the rocks, the liberated silica being deposited in the cavities in the form of opal.

An accident was responsible for the discovery of the famous White Cliffs field, New South Wales, in the year 1899, when a hunter tracking a wounded kangaroo discovered a bright bit of opal float in the county of Yungnulgra about sixty-five miles northwest from the town of Wilcannia. Following the discovery of other pieces in the same vicinity digging soon revealed opal **in situ.**

Charles Nettleton, a coal miner, saw a few opals in the town of Angeldool, and this incident later resulted in the discovery of the Lightning Ridge field about 1908. The black opal district of Tintenbar in New South Wales was discovered in approximately 1920. Stuarts Ridge field in South Australia was discovered in 1915.

According to Mr. C. S. Wilkinson, who in 1877 examined the deposit where the first discovery of opal was made in New South Wales (Rocky Bridge creek), the matrix of the opal is a horizontal layer of soft decomposed vesicular basalt, thirty feet thick, of Pliocene age. The numerous vesicular cavities in the basalt are sometimes only half filled and in other cases are completely filled with precious opal, common opal, and hyalite, which have been formed by the infiltration of siliceous waters from the rock mass. The precious variety is semi-transparent and displays fine colors of green, blue and red shades, but sizable specimens are rare.

Before leaving the discussion of the Australian fields, one thing should be emphasized in regard to prospecting. The opal miners of Australia work under difficulty due to the great scarcity of water, and during many months of the year the opal fields are abandoned entirely because of this handicap.

Czechoslovakia

In his article "Opals in the Mineralogical Collection of the British Museum", Dr. Spencer calls our attention to the fact that the opal fields formerly known as the Hungarian fields, according to present political boundaries, are located in Slovakia, a province of the new Czechoslovakian Republic.

Several gem authorities suggest that the opals of Czechoslovakia were mined in Roman times, carried by merchants to India and thence reexported to Rome as "Oriental" stones, the price increment warranting the venture, as it certainly did in the case of other gems in the Middle Ages. However, only the earliest

local archives certainly show that the Czechoslovakian mines were worked in the Fourteenth Century. At present Czechoslovakia, as a source of opals, has been almost wholly superseded by Australia.

The Czechoslovakian locality is at Czerwenitza, near Eperies (Presova), in Saros. The precious opal here occurs in fissures in a weathered andesitic lava with other forms of opal. It was formerly quarried in open workings, but now a perfect network of levels has been burrowed into the mountains.

The Czechoslovakian stones are well known in the trade and quite characteristic in appearance. Upon a milk-white background small points of red, blue, and green form a mosaic of changing hues. The Hofmuseum at Vienna possesses the finest of the opals from this region, including a single mass as big as one's fist, showing the most exquisite play of colors. This stone ranks among the finest and largest opals in the world. The Czerwenitza mines have been worked so long and so actively as to now yield few stones larger than a hazelnut. In early times farmers of the neighborhood exploited the deposits finding many of the finest stones while plowing or in rills left by the rains.

Formerly the Harlequin was obtained almost exclusively from Czechoslovakia, the principal mines being in the Libinka mountain, west of Dubnik. It is found there in the clefts and cavities of an old lava, generally brown in color, known as andesite. It is supposed that alkaline waters decomposed this rock and, setting free the silica, deposited it in a gelatinous condition, which afterwards solidified as opal. The common opal is abundant at Telkebanya. Hyalite occurs in amygdaloid at Schemnitz.

According to Ball until the discovery of the Australian mines, some fifty years ago, Hungary supplied the world with all its fine opals. The deposits were first worked, and successfully, by the peasants of the nearby village, Czerwenitza, the product being largely float. In 1788 the Hungarian government first claimed a monopoly of the mines, and underground mining was inaugurated. It was so decidedly unsuccessful that it was soon abandoned and for several decades the mines were unworked. Thereafter, the mines were farmed to individuals by whose initiative methods were improved and the industry was apparently facing a prosperous future when the rich Australian fields were discovered.

Mexico

Mexico is noted for its limpid and deep red fire opal, but its popularity is somewhat limited as this opal is more transparent than the ordinary precious opal and the colors are less fiery and apt to fade. These stones are usually brownish red with various indistinct flashes of colored lights consisting mostly of flames, red, blue, and green. The smaller and poorer Mexican opals sell by the handful, but the finer ones command high prices, and while usually considered inferior to opals from Australia and other localities they have their own particular type of beauty. We might add that the opals which were sold so extensively at tourists' resorts through the western states were generally of Mexican origin.

According to Ball, the fire opal of Mexico was probably known to the Aztecs, one evidence of which is a head of the Mexican Sun-God carved in fire opal which is probably the work of an Aztec lapidary. This is now in the Field Museum of Natural History, Chicago.

When Velasquez painted the portrait of Antonio Eusebio de Cubero, Secretary to the Governor of New Mexico about 1692, he portrayed on his finger a ring set with one of the fire opals of Zimapan. We have also an account of the wooden figure of San Juan del Rio, in the church of Jurado, State of Queretaro, which has suspended from its neck a fine celestial blue opal the size of a man's thumb. This was given as a votive offering for the speedy recovery of a near relative by one of the peon miners. The figure of this saint is carried in a procession from Jurado to the church at the "hacienda Esperanza", Queretaro, at times when the yield of opal is not prolific.

Kunz, writing in 1892, tells of opals being offered to passengers of the Mexican National Railroad, at the station of Maravatia, State of Michoacan. This so excited some enterprising dealers that an investigation was started which resulted in the opening of six or eight mines worked by about seventy-five men. Snr. Garcia reports the finding of worked opals in the mountains southeast of lake Chapola near Tiquilpan, Michoacan.

The mine at San Juan del Rio near

Queretaro still produces opals which have a certain sale among tourists. A peon found the gem by chance on the hacienda on which he worked in 1835, but systematic work has been carried on only since about 1870.

About 1927 opals, discovered in the western section of the State of Chihuahua, were examined in the geological department of Mexico City and classified as stones of good quality. The hope was expressed that this industry might be placed on a commercial footing and the stones marketed in Germany and the United States.

Opals are known to occur in Mexico in the states of Queretaro, Hidalgo, Guerrero, Michoacan, Jalisco, and San Luis Potosi. At La Esperanza, in Queretaro, the opal occurs in cavities of old volcanic lavas rich in silica. This rock is usually red, light pink, or green, and it is notable that the character of the opal varies with the character of the rock. Where the rock is red, opals with a fiery red color abound; where the porphyry is lighter or mottled, lighter colored stones are the rule. A remarkable kind of opal, of yellow or hyacinth-red color, occurs in trachytic porphyry at Zimapan in Hidalgo. This variety is not only cut **encabochon,** but is also facetted. Hyalite is found at San Luis Potosi.

At present most of the producing opal mines in Mexico are those of Queretaro. The opals are irregularly scattered in a reddish-gray spherulitic rhyolite and are indicated by the so-called **pintas** (see "Opal Glossary"). Mining is carried on by quarrying methods. In 1911 the depth of the quarry was about forty feet, of which the lower twenty-five feet produced the opals, the top fifteen feet consisting of decomposed rhyolite. The limit in depth of the opal zone is not known, but some of the older mines are still productive at over one hundred feet vertical. The working faces usually have a colored appearance and in the numerous cavities many kinds of silica have been deposited. Many of the cavities have a lining of clear brittle quartz, in which the opal is loosely contained and from which it can readily be extracted. It is thought by MacFarlane that the opal may have been the original deposit in a steam cavity. In some cases the opal fills up the entire space and is intimately joined to the rock itself, sometimes with a peripheral iron stain and again with the country rock unaltered. The occurrence apparently has no bearing on the quality of the stone, as a first grade opal may be found under any of the conditions present throughout the mine.

The opals are cut and polished at the city of Queretaro. The first operation is the rough shaping on an ordinary large grindstone. When the stone has been ground to the largest possible size consistent with symmetry and beauty, it is passed on to the sandpapering machine and is given its final polish by vigorous rubbing on soft, rough leather, and the opal is ready for market.

India

In the Bombay district, numerous fine specimens of milk-white opal, with a flame colored iridescence, are procured on the banks of the Sina river, between Andargaon and Paranda. In Nagpur, in the Central Provinces of India, opal is sometimes found filling cracks in the manganese ores. Good examples have been found at Kandir and Kodegaon.

Opals are found with chalcedony, carnelian, and amethyst near Hyderabad City. In the Madras district, on the east coast of the peninsula, opal is of common occurrence. In the manganese-silicate rocks of both the kodurite and gondite series quartz is commonly found as an original mineral. As the result of the chemical changes that have taken place in these rocks, however, there has often been a considerable production of secondary silica; this does not form as quartz, but as either opal or chalcedony. Opal is also not infrequently common in the Vizagapatam mines, as a replacing material for the felspathic portion of kodurite, the product frequently taking the form of manganese-garnet set in a matrix of opal. Good examples of this are seen at Kotakarra, Kodur, and at Boirani in Ganjam.

At Ajmer in the Rajputana district, massive milk-white opal is found at the base of the hills near Srinagar.

United States

Inasmuch as the opal deposits of California and Nevada are discussed elsewhere in this issue, I shall not consider the United States' occurrence of opal

here. It suffices to say that Nevada ranks fourth in importance as an opal producer. The following photograph by Sterrett shows opal mining conditions in Virgin Valley, Humboldt County.

Honduras

It is impossible here to describe all the known localities of opal as there are small deposits in many places throughout the world. According to Ball, von Leonhard described the Gracios o Dios opal mines of Honduras in 1843, and they were doubtless known for some time previously. Brigham states that the pre-Colombian Quiche procured the opals used in their jewelry from Honduras.

Those interested in the sentiments and anniversaries connected with the opal would do well to refer to several of the books by Dr. Kunz. He points out, for instance, that the gem for him who is named Osmond is opal, and for her who is named Frances it is the fire opal. The fire opal is symbolic of the sixth hour of the day and the entire summer season and it is also the birth-stone of the month of October. The planetary influence of opal is attached to the sun and to Mercury; and the significance of dreaming of opals is great possessions. The national gem of Hungary and New South Wales is the opal, and it is also claimed by the state of Idaho.

January 20, 1933.

G. FREDERICK SHEPHERD.

Courtesy U. S. Geological Survey.

Opal Mining, Virgin Valley, Nevada.

Opals in The United States National Museum*

——*By*——

WILLIAM F. FOSHAG

Curator of Mineralogy, U. S. National Museum

The mineral and gem collections of the United States National Museum are exceptionally rich in that delightful mineral, the opal. Not only did the original collection contain some fine material but the mineral was a favorite with Colonel Roebling, whose collections, now a part of the National collections, contained several specimens of unusual character as well as lesser ones too numerous to be mentioned here, where the finer material only can be briefly described.

Perhaps the most unique stone of the Roebling collection is a fossilized vertebra of an extinct animal found in the opal mines of White Cliffs, New South Wales. A thin crust dims the splendor of most of the specimen, but even this cannot hide the beauty contained within. Where the stone has been chipped about the edges, opal of the finest quality shines forth. The vertebra weighs an even half pound and is so perfectly preserved that the nature of the animal has been readily determined as a plesiosaur, a swimming reptile that lived in the Cretaceous seas. The translucency of the stone indicates that no portion of it is original bone or even common opal, but is of gem quality throughout.

A second specimen of unusual interest is a large pitch-black mass with broad, vivid flashes of red and green. This came from the opal fields of Virgin Valley, Humboldt County, Nevada. It is said that this mass was originally a part of the bark of a tree the main portion of which was changed for the most part to the common grade of opal. This stone weighs 533 grams or 2665 carats and is said to be the largest mass of precious opal known.

Similar opals of a black pitchy color from the same locality are also included in the Roebling collection. One, an egg-shaped mass of 72 grams (360 carats) is a blaze of red and green fire on one side and of red and yellow on the other, the color appearing as a mosaic pattern simulating the magnified scaly wing of some tropical butterfly. In proper light no part of the stone's surface is without color. Two flat slabs weigh 117 grams (585 carats) and 47 grams (235 carats.)

Among other Nevada opals are 16 large specimens showing the varied color range and patterns of the opals from this locality, 4 large masses of opalized wood with veins of precious material, and a great number of smaller specimens. One specimen, presented to the Museum by Mr. William B. Pitts is a small cone or bud transformed to precious mineral.

Three large specimens of opal in limonitic matrix, from the Barcoo River, Queensland, among the best of the Australian specimens in the collection, were presented by Dr. L. T. Chamberlain and three fine slabs of similar material are in the Roebling collection. White Cliffs, New South Wales, is represented by a polished slab of pure opal weighing 220 grams (1100 carats), several of the so-called "pineapples"—opal replacing clusters of glauberite crystals—opalized shells and opalized wood with streaks of material of good fire.

Large, showy opals from the Mexican fields are very rare but a few good examples of the precious material imbedded in rhyolite matrix are present.

The Isaac Lea collection of gems contains a fine series of cut opals. These are difficult of description since they vary with each movement and ray of light. The finest of Mexican opals are quite rare, and it is a matter of dispute, settled only by personal preference,

*Published by permission of the Secretary of the Smithsonian Institution.

whether or not these are surpassed in beauty by the black opals from Lightning Ridge, New South Wales. The suite of Mexican stones in the collection is particularly rich and fine, including two fine yellowish colored ones of 21½ carats each, with a fine play of brilliant color, and four smaller ones of the same brilliant yellows and reds; two of the "harlequin" variety, one of which, weighing 14½ carats, is of the finest quality; seven white stones with small points of color are also harlequins but not so brilliant. Three topaz-colored facetted stones are quite unusual.

The Australian stones include a fine black one of 24 carats from Lightning Ridge, and from Queensland are; one large oval stone with blue and green colors, 60 carats; a triangular stone with much red, 36 carats; a rectangular stone with broad peacock flashes, 60 carats; a carved pansy, 9 carats; and two beautifully engraved opal flamingoes and a large opal lizard on limonite matrix.

The finest of the Hungarian stones is a well cut cameo of 30 carats.

While this list does not exhaust the opal material in the collection, the finest stones are included. No description can, however, convey to the mind the exquisite beauty of these gems.

The Geology of Opal

—By—

GILBERT HART

Opal is a fairly common mineral which is always of comparatively recent origin. Chemically it is a rather indefinite compound of silica and water, the water content being variable and perhaps not in any exact molecular relation. Deposition of silica from aqueous solutions results in the formation of a jelly-like substance of similar indefinite relation between water and silica. Originally opal was probably such a colloidal gel, which has hardened by evaporation of the occluded water. Opal is geologically unstable, since in time there is a recrystallization of the amorphous jelly, giving rise to the microcrystalline chalcedonies. It is probable that these in turn are further devitrified to form jaspers and granular quartz deposits.

Silica, when deposited from fusion or complex silicate or sulphide melts, is most commonly crystallized as quartz, with or without the intermediary cristobalite or tridymite. It is only from aqueous solutions that the opal-jelly is formed, and opal occurs now only where such siliceous solutions have acted in the later geological periods. The study of opal occurrences is that of recent to late Cretaceous bodies, which have been deposited under conditions which allowed the activities of silica-bearing waters.

Opal is being formed in many ways at the present time. Even organic fluids may become impregnated with silica and deposit within the organic tissues varied opaline types. The shell-cases of microscopic plants, diatoms, are of opal-silica. Diatoms have existed in many previous ages, and accumulations of their cases often form thick rock bodies of diatomaceous earth. Such bodies are often exploited for various purposes, such as for heat-insulation or polishing powder. The spicules of many sponges are similarly formed of opal-silica.

Another of the organic opals is tabasheer, nodules of which are deposited by vegetable solutions in joints of bamboo. Such irregular lumps are usually of hyalite or hydrophane opal, more or less transparent, and with distinct fire only when immersed in water. Very rarely there are grown larger grains, with delicate organic pigmentation and natural fires which furnish a highly prized Oriental gem.

These organic silicas furnish much of the material for ground-waters which dissolve and reprecipitate opal in sediments.

Siliceous limestone and shell-rocks are frequently traversed by narrow seams of common opal, and often opal replaces organic matter as in opalized wood. The activity of solution and opalization may be greatly later in age than the original deposition of the clastic material. Opalized wood from the Permian of Kansas may have been so formed since the activities of early Cretaceous time, at the close of the building of the Nehama Mountains. The flints of the older limestones are secretions originally derived from such organic opals as sponge spicules and diatoms. Many such secretions show traces of former presence of opal.

Hot waters from subterranean igneous bodies dissolve silica from the various rocks as they pass. Often on traversing cooler rocks opal is deposited in fissures or other cavities. Such deposits are found in either igneous or sedimentary rocks, and usually are of common dull opal.

These same waters may reach the surface as hot springs, and if charged with silica the reduction of pressure and temperature cause depositions of the opal on the edges of the springs. Siliceous sinter is opal, often impure thru the admixture of other materials dissolved in the waters.

Finally opals are rarely noticed in stream gravels, with heavy minerals. Such accumulations are rare because opal is appreciably soluable in water, and it is usually too brittle to survive any long river transport.

The various types of deposits generally include the common opal. This is mineralogically identical with the precious opal, but is impure by mixture of clay, ocher, and other such substances. In the sedimentary rocks most of the opal is of this type, often dark in color, and entirely wanting in fire. Opalized wood is likely to occur in any post-Devonian sediments, provided since early Tertiary times warm waters have percolated thru. Such material is usually without fire, but may be sufficiently brilliant in color to be cut as a gem.

Sinter deposits of hot-springs usually are of dull grey colors, occasionally pearl-sinter of delicate color and fibrous structure is worthy of a place as an ornamental stone. The underground continuation of such sinters, the low temperature mineral veins, sometimes carry opal, but not usually of gem quality.

Aside from the occasional finding of fire-opals in these types of deposits, precious opals are confined to deposits formed by the action of hot waters on recently formed igneous rocks. Silica is dissolved by the liquids which represent a late phase of the cooling and solidification of the lavas. Sometimes it is an original constituent, being residual in the final watery mother-liquor remaining after the crystallization of the silicates; more often the hot magmatic waters dissolve the siliceous glass of the volcanic rocks which they traverse. If the lavas were associated with beds of ash, which are composed of fragments of glassy rocks, solution is easier and soon becomes saturated.

Important deposits of precious opal are to be found in areas of the most recent mountain-building activity; the Andes-Rocky Mountain system in the Western hemisphere, and the Himalaya-Caucasus-Alps system of Eurasia. Usually these deposits are either in volcanic rocks, flows or ash-beds, or in fine-grained sediments closely associated with such effusives. Other articles in this issue of ROCKS AND MINERALS tell of the details of several of these localities, and the interested student will refer to the geological publications of Queensland, of Germany, or of the United States for further reports.

The first National Outing of the Rocks and Minerals Association will be held on July 9, 1933. Fifteen states to date will be represented. Members and their friends are urged to give their full support to this very worthy project. See Preliminary Announcement on the back cover of this issue.

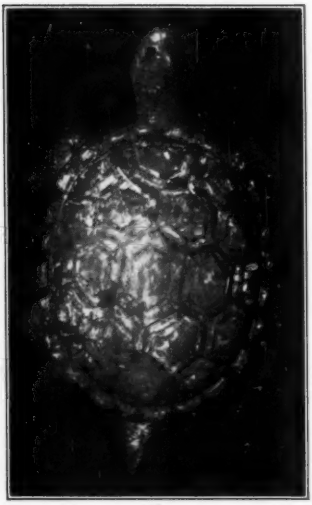
Are you interested in a directory of mineralogists of the world? An opportunity is open every one to assist in the issuance of and be represented in a "Who's Who In Mineralogy" at a very nominal cost. See Ad. page 3 in this issue for full details. Who will be the first to rush in his order?

The Opals of the Morgan Gem Collection

—*By*—

HERBERT P. WHITLOCK

The curator of every large public collection is constantly confronted by an important problem which is seldom brought to the attention of the casual visitor for whose interest and edification the collection has been mainly prepared. I mean the coordination and balance between its various parts which admits of a proper representation of them without an undue emphasis upon any of them. On the one hand, for instance, a collector from Maine or from California will, perhaps, be disappointed because he does not find a considerable space devoted to the specimens, we will say of tourmalines, with which he is familiar, and of which he has in his own collection a very large showing. On the other hand, a wise curator will make every effort to secure fine and representative examples of every important occurrence which may be logically included in the field covered by his particular branch, whether it be building materials or butterflies, firearms or fishes.



Courtesy
American Museum of Natural History.

Turtle carved from opal from White Cliffs, N. S. W., Australia.

The Morgan Gem Collection in the American Museum of Natural History was built upon the uniquely representative series of gem stones assembled by the late Dr. George F. Kunz for the Paris expositions of 1889 and 1900, and subsequently purchased for the Museum by Mr. J. Pierpont Morgan.

Among a number of Mexican fire opals from this collection is a cabochon cut stone of 17¾ carats weight that was said to be "the finest stone ever produced from a Mexican mine." Late in the Nineteenth Century (1889) the White Cliff deposit in New South Wales was discovered, in ample time to be represented in the second gem collection bought by Mr. Morgan for the American Museum by several notable pieces, especially a polished matrix with beautiful violet reflections in mass flash. From the same locality comes a section of saurian bone replaced by precious opal which is 20 inches long and about 5 inches thick, the gift of Mr. George S. Bowdoin; and a polished mass of precious opal the gift of Mrs. George M. Gould.

The black opals of Lightning Ridge, New South Wales and Barcoo River, Queensland, are represented in the second Morgan Gem Collection by a heart-shaped cabochon and a polished slab of very fine intense blue flash, as well as several of the mosaics characteristic of this occurrence and period.

Within the last three years an effort has been made to bring the opal section of the Gem Collection up to a standard comparable to the high general quality and exceptional individual pieces that characterize the other portions of this famous display. As a result of this drive for finer opals, the Collection can show a

Courtesy
American Museum of Natural History.

Cameo Head carved from opal and matrix from Stuart Range, South Australia.

group of stones of high quality selected to show all of the principal variations of color and flash to be found among the Australian occurrences; also a peacock carved in low cameo relief from Lightning Ridge black opal.

Recent Australian finds are represented by the cameo head of an Indian with feathered headdress, carved from Mayneside, West Queensland opal, in which the dark jasper matrix, forming the face, contrasts well with the iridescent opal feathers. Another cameo carver in opal has produced from the material recently discovered in the Stuart Range of South Australia, a very lovely head wrapped in a scarf. In this piece the delicate egg-shell color of the matrix is used for the face, against which the light tinted color play of this kind of opal, from which the folds of the scarf are carved, gives a fine contrast.

Nevada opals are well represented in this Collection by polished masses in all the wonderful gamut of colors for which the Virgin Valley stones are famous, as well as by the most perfect example of wood replaced by **precious opal** which the writer has as yet seen. The latter specimen, a polished slab 4x2½x¾ inches, outlining in flashing fire every detail of texture of this old piece of tree, has a somewhat romantic history. Five years ago this piece was left with the proprietor of a general store in a certain Nevada town by an old prospector as a grubstake. This ancient took his supplies and followed the rainbow lure of the opal. No doubt the desert claimed him for he never returned, and his pledge is now in the Morgan Collection. We call it the "Grubstake Opal."

Courtesy
American Museum of Natural History.

Peacock carved in low relief from black opal from Lightning Ridge, N. S. W., Australia.

TWO IMPORTANT ANNOUNCEMENTS

See Ad. page 3 and back of cover of this issue.

Opals in the Mineralogical Collection of the British Museum

—— *By* ——

DR. L. J. SPENCER, F.R.S.
Keeper of Minerals

Starting this short article with a few bald statistics, we may say that the collection contains 776 specimens of opal, representing 239 opal localities in all parts of the world. The exhibited specimens occupy a 13-foot run of the table cases with a width of 26 inches. A few other specimens, too large for the table-cases, are displayed in a glazed case-end and in a wall-case. Unexhibited specimens are stored in 26 drawers (each 22x18 inches) beneath the table-cases. The total space occupied is thus rather over a hundred square feet.

The exhibited specimens are grouped in order of the varieties of opal, namely, hyalite, precious opal, hydrophane, fire-opal, milk-opal, prase-opal, rose-opal, opal-agate, wood-opal, forcherite, menilite, semi-opal, cacholong, fiorite, siliceous sinter, tripolite, diatomite, jasper-opal, pealite, alumocalcite. Unexhibited specimens are arranged in the drawers according to locality; for example, opal (apart from siliceous sinter) from the United States and Canada being kept together in but one drawer.

Amongst the exhibited specimens there are ninety-eight cut stones of various types, and there are large showy specimens in the matrix of the old Hungarian and the newer Australian precious opal, and large blocks of Mexican fire-opal. The systematic registration of every individual specimen in the mineral collection was not commenced until the year 1837, and consequently the history of many of the older specimens has unfortunately been lost. Only one specimen can now be definitely identified as having come with the collection of Sir Hans Sloane, which formed the nucleus of the British Museum in 1753. Also only a single specimen can be identified from the collection of Baron Ignaz von Born, this being mentioned in his catalogue **"Lithophylacium Bornianum"** (Prague, 1772). But several specimens from the collections of the Rev. C. M. Cracherode (bequeathed 1799) and of Baron F. C. von Beroldingen (purchased 1816) still bear their original numbers which refer to the old manuscript catalogues.

A fine set of specimens of blue precious opal in a brown matrix of siliceous ironstone from Barcoo River, Queensland, was presented by Prof. N. S. Maskelyne in 1887. These were from the first lot of precious opals to come from Australia, before the discovery (in 1889) of the better known locality at White Cliffs in New South Wales. A good piece of this blue opal from Queensland, formerly in the collection of John Ruskin and figured in the frontispiece of his **"Deucalion"** (Vol. 26, of his Collected Works), is also shown.

Amongst the specimens from White Cliffs in New South Wales, is an opalized fossil bone—the humerus of a plesiosaurus—22 cm. long and 11 cm. at the widest part (8½x4¼ inches), which consists entirely of gem opal. Other opalized fossils from the same locality are univalve and bivalve shells, belemnites, and wood. Rough and cut specimens of the "black opal" from Lightning Ridge, New South Wales, are shown in the opal case, but the best cut specimens of this are in a special case containing the collection of cut gem-stones formed by the late Sir Arthur Church, and presented by Lady Church in 1915.

An attempt is being made to include in the collection specimens of precious opal from all the localities where it has been found in Australia. The following are so far represented in the collection.

Queensland:

Barcoo River (near Blackall), Tambo County.

Coochin Coochin, Dugandan, Ward County.

Eromanga, Gordon County.
Friday mine, Keeroongooloo, Kyabra County.
Listowell Downs opal mine, Blackwater Creek, Bulloo River, McKinlay County.
Mayneside, Binburie County.
Mt. Thight, Barcoo County.
Opalton, Fermoy County.
Warbreccan, Musgrave County.
Yowah, Wellington County.
("near Bourke"?)

New South Wales:
Lightning Ridge, Walgett, Denham County.
Tintinbar, Balinar, Rouse County.
White Cliffs, Yungnulgra County.

South Australia:
Coober Pedy, Stuart Range.

The locality of the old Hungarian precious opal has now passed into another country; or rather the boundaries of the countries have been altered, the opal locality remaining just where it always was. It is now in Slovakia, a province of the new Czechoslovakian Republic. In the mineralogical textbooks it is usually stated as "Czerwenitza, Hungary."

The T. C. Wollaston Collection of Opals

By

THOMAS W. FLUHR, A.M.

A marvel of light and color, shimmering in the sunlight like the ever-changing flames from a driftwood fire, was the T. C. Wollaston collection as it was spread before me. Mr. Lucian Zell, in whose possession the collection now is, handled the pieces tenderly, turning each in the light, that the fullness of its iridescence might be better displayed, and then laying it back on its bed of cotton wool.

Pelecypods and gastropods (clams and snails) were there, and the precious opal which has replaced their former shells makes them look more alive than when they lived and died on the shores of some ancient Cretaceous sea. In a piece of opalized wood were the lowly borers, (Teredina) replaced in precious opal. Nor were the vertebrates missing. Part of a backbone and some of the ribs of a reptile, and numerous joints gave evidence of the life of that time. In one of the bones a fracture showed the internal structure of the bone so well-preserved that one might almost imagine that some of the blood was still in it. The long cones of Belemnites were there. There too was something that looked like fossil coral; delicate cellular structures resembling Favosites. These organisms died and were buried in the sands and mud of that ancient time, but today, reincarnated in precious opal they live again.

There were inorganic forms too. A "Pineapple" opal, in shape similar to the fruit after which it is named; a replacement of a clump of crystals supposed to have been gypsum. An oval piece about four inches in diameter resembled a conglomerate or pudding-stone, with the cementing material and part of the pebbles replaced by precious opal. There was one piece with bands of opal displaced along a fault. Numerous "Kernel" opals had the structure of agates, an outer rim of silicious iron-stained material, a light-colored band inside it, and a center or kernel of precious opal, very much like a nut; in fact they have been called "Yowah Nuts."

About two dozen specimens had been polished, among them many specimens of "Black opal" from Lightning Ridge. Held in the light these showed all sorts of harlequin and checkered patterns, never constant, but ever changing as the piece was moved. Iridescent deep blues and greens, occasional sheens of red, all the colors, and combinations of colors such as are not to be seen in the rainbow itself.

(*Continued on Page Eighteen*)

Opals in Virgin Valley, Nevada

—— *By* ——

DR. H. C. DAKE

The Virgin Valley opal locality is situated in Virgin Valley, Humbolt county, Nevada, about twenty miles south of the Oregon boundary line. The locality can be best reached by two auto routes, either via Alturas, California or via Burns, and Denio, Oregon. The distance from Alturas is about one hundred miles and from Burns about one hundred and seventy miles. Both auto roads while passable are quite rough. Drinking water should be carried as water is available at only a few places in the entire region. The valley is a semi-arid, treeless region lying at an elevation of about five thousand feet, a typical western sage brush covered "valley." Aside from two widely separated ranches the area is uninhabited by permanet residents.

Mining here has never been continuous and most of the work is done in the cooler months of the year. At some of the claims only the annual assessment work is done. The infrequent rain storms of the region, may be erosion, expose an outcropping of precious opal and lucky indeed is the prospector or sheepherder who stumbles onto such a deposit. Practically all the opal mined is found very near the surface, most of the old workings are merely shallow open cuts, few being over six feet in depth.

In Virgin Valley we have what is conceded to be the largest opal deposit in America, the largest both in extent and in the quantity of opal found. Opal was first discovered here in 1908. The most valuable finds were made at the Rainbow Ridge mine, which in 1919 produced the well known black opal that weighed nearly seventeen ounces and was valued at one fourth of a million dollars. This magnificent specimen eventually found its way into the collection of the late Colonel Roebling and is now known as the Roebling opal. It is probably the world's most valuable black opal.

The opal occurs in a soft sedimentary volcanic ash and tuff matrix of Miocene and perhaps pre-Miocene age. In places the beds are a thousand feet or more in thickness, having been protected from

1931

Mine and mine building of the Rainbow Ridge Mine, Virgin Valley, Humboldt Co., Nevada. It was from this mine that in 1919 the most valuable or at least one of the most valuable opals mined in modern times was obtained. It was the famous "black opal", valued at one-quarter million dollars, originally in the Roebling Collection, and now is in the U. S. National Museum. The specimen has never been cut. Rainbow Ridge is the low-lying hill in the foreground.

rapid erosion by the presence of a thick "capping" of the later Miocene lavas. The sedimentary beds of Virgin Valley can be divided into three series; upper, middle and lower beds. The upper beds are soft in texture, of a light color, and carry an abundance of mammilian fossil remains. The middle beds are of a brown and gray color, and contain floral fossils, petrified wood in large quantities, as well as the opal. The lower beds are probably of pre-Miocene age (Eocene) and are much harder and more consolidated than the others.

Virgin Valley opal is unique in that practically all of it is found pseudomorphic after wood, limbs and twigs of trees and even bones. In some specimens the structure of the original wood is completely lost, but yet preserving the shape of the wood growth. These are classed as "casts" of wood. In other specimens the wood structure is very evident, but "petrified" with a beautiful fire opal. The opalized wood of this locality is the most magnificent seen by the writer and is probably equal to the best found anywhere. A large amount of ordinary silicified wood is present in nearly all parts of the valley. At many of the opal diggings large trunks of petrified trees are still standing in their original vertical positions.

The opal occurs in many different colors ranking from the clear white material to that which is completely black and nearly opaque. A great deal of clear green and red "fire" opal has been found, even in large masses, but owing to the presence of small fractures much of it is unsuitable for gem cutting, but if left as taken from the diggings it makes wonderful cabinet material. Some of the nearly opaque brown and white opal shows a good play of colors and when free of fractures will cut into fine gems.

The black opal found here is indeed of very fine quality, often occuring in large spectacular masses. Some of it is rounded and curved like the limb of a tree, often four inches or more in diameter, with the inner wood portion showing a fine green and red color play and with the outer bark portion forming a thin crust of magnificent black opal. It has been the observation of the writer that a great deal of the Virgin Valley pseudomorphous opal occurs with the inner or "wood" portion of most any type of light colored opal, while the outer original "bark" is black opal. The writer cannot offer a satisfactor explanation as to the reason why only the bark of the wood becomes black opal, in the majority of specimens examined. The precious black opal of Virgin Valley is quite different from that found in Australia, the Nevada material being generally more translucent, and in the opinion of the writer the Nevada material is equal or superior for specimen purposes. However, the Nevada material, being more brittle and subject to fracturing, does not offer the cutting possibilities of the Australian black opal. The Virgin Valley black opal often occurs clear and quite translucent, with the finer specimens showing a blazing mass of green, red and purple "fire," against a black background, the effect of which is beyond descriptive words.

Due to the fragility and fracturing habits of the Nevada opal when first mined, most of it is put thru a "curing" process before an attempt is made to cut gems. Some of these curing processes are undoubtedly of more or less value,

A characteristic opal mine. Virgin Valley, Nevada. Most of the "mines" are shallow diggings of this type.

provided the material is not too badly fractured when first mined. Lapidaries report instances where some of this opal has "exploded" in relatively small fragments, during cutting or a short time following cutting, due no doubt to an internal stress within the material, and can probably best be accounted for on the theory that the opal has been subjected to a more or less sudden dessication after being mined. The minute cracks often seen in the Nevada opal do not seem to run from the outside to within, but extend from the inside to within a short distance of the outer surface, indicating an internal stress.

A number of "curing" methods have been tried with varying degrees of success, such as, submersion in water, oil, vaseline, glycerine and water solution and other substances. Some of the miners immediately wrap the better opals in cloths saturated with water and glycerine to prevent any sudden dessication by the dry atmosphere of the locality. Another method used by the miners is simply that of packing the opals in large tin cans, with the dirt from the mine. The opal is kept packed in this dirt matrix for a period of time varying from one to five years, the object being to permit only a gradual dessication to take place. The miners consider the opal "cured" when the thin outer sandstone crust can be readily peeled from the rough opal by the use of a sharp instrument like a pocket knife blade. In some instances the opal is extensively fractured and cracked even when first mined, rendering it suitable only for specimen purposes. If some of the thin sandstone crust be left upon this specimen material it will serve to help prevent any further extensive fracturing. Many very fine cut gems of Nevada opal have become nearly worthless after a period of time, due to the development of areas of "checking", which ultimately end in a fracture. This is usually the result of improper curing, cutting or handling of the gem material.

Various methods are pursued by the lapidaries in the curing treatment of Nevada opal prior to cutting. The common method of soaking the opal in glycerine and water solution is used with the idea of replacing some of the water content of the opal with glycerine, which does not evaporate.

The writer has had the opportunity of observing a curing process used successfully by a well-known lapidary. The process used consists essentially of altering the proportional content of the water and silica in the opal by the use of heat and high pressure, thus rendering the opal much less friable and durable.

Some claims have been made that the color and "fire" in opal can be enhanced by certain curing processes, but such claims are without doubt unsupported by facts. All that can be expected of any curing process is to render the opal more permanent and durable, physically.

During recent years the Virgin Valley region has yielded a large number of fine specimens both of opal and opalized wood, which can be seen in most of the large mineral collections of the country.

THE T. C. WOLLASTON COLLECTION OF OPALS

(Continued from Page Fifteen)

This collection is the fruit of forty years of work by the late T. C. Wollaston in the gem fields of Australia. Wollaston has written an interesting book, "Opal: The Gem of the Never Never", which is replete with information concerning opal and Wollaston's life spent in collecting it.

It is futile to attempt to describe this collection; words can merely hint at its beauty. The collection belongs in a museum, not hidden away from the eyes of the world.

The writer is indebted to Mr. Lucian Zell, of 522 Fifth Avenue, New York City, for the opportunity to examine this splendid collection, and for much information concerning it.

In Quest of the Opal

— *By* —

H. T. STRONG

One hundred and sixty-seven miles north of Mexico City and in one of the most fertile valleys of all Mexico lies the very old and historic city of Queretaro, with a population of nearly 40,000. This city of beautiful old Cathedrals lies at an elevation of 6,000 feet above sea level and was founded by the Otomie Indians in 1440, captured by the Spaniards in 1531 and named by them Santiago de Queretaro.

In 1808 Queretaro became the cradle of Mexican Independence by casting off the yoke of Spain. Here stands the church in most excellent repair where the Great Archduke Maximillian was executed (shot) in 1867.

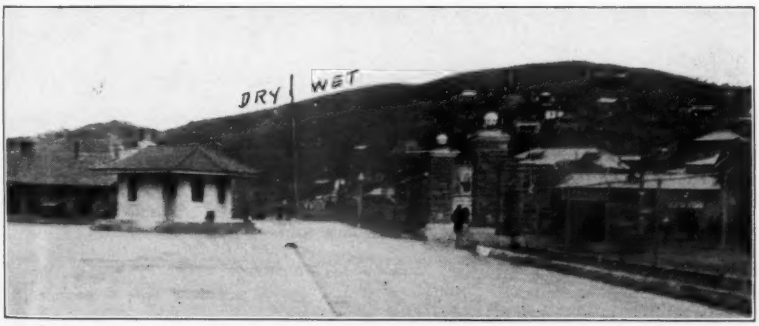
Any mention of the name 'Queretaro' had always interested me greatly as I knew it to be the center of the opal mining industry of the Western Hemisphere, and to me the power of the refraction seen in the rainbow, the opal, the humming bird and Morpho butterflies, is amongst the most fascinating of all nature's color phenomena.

For the third successive winter, I had sought the warm sunshiny days of Tucson, Arizona, to avoid the extreme cold of New York. One day I accidently heard that the Southern Pacific Railroad was advertising a very low excursion rate from Tucson to Mexico City. I immediately thought of Queretaro and decided to take the trip in quest of opals. The next thing was to find a congenial companion for the trip. I thought of my very good Rotarian brother, Dean G. M. Butler, Head of the School of Mines of the University of Arizona and State Geologist. In five minutes I had his name on 'the dotted line' and on the 16th of January, 1931, we boarded the S. P. R. R. for Mexico City.

Our first stop was Nogales, where we changed our American paper money into Mexican silver. I started to change a $100 bill into silver pesos, but soon changed my mind when I realized I would have to employ an assistant to help me carry it,—more than 250 silver dollars. Imagine the weight! I changed $25 for 71 silver pesos, and that was all I wanted to carry.

A very high and imposing wire fence goes directly through the center of the main street of Nogales; one side of this street (Mexican) is very wet, the other side (American) is dry (at least to all outward appearance).

And now we realized we were in a country where time has no value and



The fence, through the center of the main street of Nogales, marks the International boundary line between Mexico (right), and the United States (left.)

where the word 'hurry' was taken out of the dictionary.

The first important stop, Guaymas, bids fair to become one of America's greatest playgrounds, for it gives access to all the virgin waters of the Gulf of California and is the finest fishing grounds in all North America.

We spent the next day going through small Mexican villages so entirely different from anything in the States that one is greatly impressed with the old saying, "one half of the world doesn't know how the other half lives." At every village the picturesque natives were selling various kinds of fruit, sweet cakes, tortillas, coffee and flowers. They were all wrapped to the eyes on cold mornings with colorful blankets (zarapes), wide sombreros on their heads and either barefooted or wearing sandals. The train carried many second-class cars packed with peons who are the best customers of the venders and who lean out of the windows at every station buying food.

Some one remarked that the peons were a very strong race of people; after passing through one of the cars in the early morning as they were eating their breakfast I realized he spoke the truth.

After passing through many little villages, we came to the city of Tepic. For the next hour one may imagine himself in the Swiss Alps as the wild Nayarit Mountains are crossed. The 62 miles of track between Tepic and La Quemada cost fourteen million dollars; 15 miles of track being laid with ebony ties. This bit of railroad represents the most costly as well as the most difficult rail construction in the world.

Our next important stop was Guadalajara; second city in size in Mexico. We stopped here for four hours. The drive through the city shows that the people are extremely fond of flowers, the most beautiful of which are the poinsettias, double and single, and the bougainvilla. I have never, in Europe or the States, seen flowers so strikingly beautiful as the double poinsettias growing on trees on many of the lawns.

All aboard! and we are off for Mexico City. The view, just before reaching the city, of the two snow-capped mountains (Valeanos) Popocatepetl (the mountain that smokes), and Izlaccihuatl (the sleeping lady), is one never to be forgotten.

There was great excitement and much jabbering as we disembark at Mexico City. We decided to stay a few days at the Ritz Hotel. We found our rooms cheerful and very clean. We went at once to the Bank of Mexico to get more silver and on the way back one of the many sellers of lottery tickets shoves a long sheaf of them in front of me, requesting me to purchase. I instantly feel for my watch and fob,—they are gone and so is the ticket seller! I try to locate him in the crowded street but without success, so I repair to the nearest jewelry store and buy an 'Essex' for 3 pesos ($1.25), which has the Mexican 24-hour dial.

I have traveled three days on a slow bumpy train to buy opals so I start out with my pockets bulging with silver pesos. I call on several jewelry stores, asking for opals (opalos) but find none worth considering. Finally one jeweler brings out a very beautiful one. I price it. One thousand pesos! In the States I had turned one down as handsome for $100 and this one is $400—and in Mexico! Later on I secured some opal matrix and cut stones at Weston's Curio Shop, the only place in the entire city that really carried a stock of opals. The cut stones were very high in price and only one interesting piece of matrix which I bought for 15 pesos.

Very much disappointed, we started off for Queretaro, arriving soon after lunch. We were recommended to the Hotel International as the best. We deposited our baggage, getting out of the room and into the warm sunshine as quickly as possible. We whistled and both thought of the same thing. I started out on a tour of inspection and found a small new hotel opened only two weeks ago. The

A familiar scene in Mexico—father and the boys riding—mother, mother-in-law and the girls, walking. (Taken enroute to the opal mines.)

rooms were cleaner and more livable. I took two porters back with me to the International, paid our bills there and then transferred our belongings to the "Jardin", where everything possible was done to make us comfortable and happy.

We walked through every business street of the town, not an opal was to be seen in any of the shop windows; back to the hotel we went, made some inquiries and finally secured a guide to lead us to the home of a local lapidary who showed us a few fair cut stones and two or three small pieces of matrix. I bought them all. Next our guide led us to another private home and there we found some really beautiful cut stones, moderately high in price, but very unusual. This old fellow relieved me of much weight in silver.

We next met the man who owns several opal mines near Queretaro and from him obtained our first interesting information regarding Mexican opals. This man, Joaquim Ontivaros, speaks English fluently and has a very charming manner. He offered to take us to his mines the next day. We accepted his invitation and next morning at 10:30 started out in a closed car over the roughest road I have ever traveled. It took us four hours to cover 72 kilometers (less than 60 miles) and the old Plymouth doing its best every minute. We had covered 40 miles when 'bang' went the steering gear. We walked back, found the missing nut, fixed the car up and we were off again. Five miles more and the fixtures came apart again, nearly upsetting us. We spent half an hour looking for the missing nut but without success. What were we to do,—45 miles from town and no relief in sight? Finally the chauffeur found a piece of wire and bound the steering gear together. We talked it over and decided to go on. The wire held and we finally reached the opal mines, at the foot of a beautiful mountain. We had gone for miles over country where no road ever existed.

There are about 150 opal mines around Queretaro. At the time of our visit not one was operating. Our friend has the largest and richest mines and he was expecting to open his up again in a week or so. He pays for common labor 1 peso 25 centavos (50c American money) for 8 hours work. Most of his opals are sent to Idar, Germany, where they are prepared for market and sent chiefly to India and Japan.

Some of the finest Mexican opals have come from this temporarily discarded opal mine. Note the Indian woman washing her husband's clothes while he takes a bath—the clothes (all he owns) are dry by the time he has finished his bath and every one is happy.

Color Play in Opal

——*By*——

H. E. BRIGGS

Kalispell, Montana

Opal is one of the most beautiful gems known to man. But many and varied, however, are the superstitions and myths connected with this mineral. The Turks believed it fell from heaven in a flash of lightning and it is a pity this beautitful theory cannot be substantiated.

It would seem that the opal with all its beautiful and wondrous play of color must be a very complex gem. This may be true in many ways but from the viewpoint of a chemist, the opal is one of the simplest of minerals consisting merely of silica and water. Whence, then, the wondrous play of color? is the question which presents itself to most of us.

Sir Isaac Newton, after a long study of this gem, declared the color play to be produced by tiny fissures in the structure of the gem. Mohrs, on the other hand, maintained that these thin air-filled fissures would only produce iridescence. As we often meet with quartz and shattered glass which show quite a bit of color play due to fractured structures, this no doubt was one of the facts which caused Newton to draw his conclusions. While it is true that opal is a very porous gem, as gems go, yet it can be proved that color play can exist where fissures are absent or in such an arrangement that they do not correspond to the color play which presents itself.

The writer has experimented with many varieties of opal. Hyalite, for example, was subjected to heat and cooled quickly; this produced a myriad of minute fissures. And the experiment substantiated Mohrs' theory that such fissures would cause only iridescence. Other varieties were experimented on with the view to produce, by synthetic means or to intensify, the color play in the stone. All such experiments only led to failure. The writer then made another series of experiments with the view to determine, if possible, the true cause of color play in opal. A number of sections were prepared from various opals showing color play and more especially from stones where the color appeared to lay in strata form. A specially designed refractometer was used in the experiments and the findings showed conclusively that the index of refraction in opal varies throughout the gem where color play is shown. In some cases this difference in refraction is due to the variable amount of water which is present in the structure of the gem. In other cases it may possibly be due to metallic salts present in the gem. It is the opinion of the writer that salts of metals do not play as important a part as does the aqueous content for the reason that every sample experimented on lost all its color play when thoroughly desiccated. And attempts failed entirely to restore the color play in stones which had been thoroughly desiccated. Various methods for introducing water in the desiccated opals were used from soaking in water to treating with live steam. Many solutions were also used and different forms of radiant energy. All these attempts brought forth only negative results.

The writer has had great difficulty in working some opals mined in the United States, Mexico and Honduras. These gems have a tendency to crack and explode after cutting. And many of them are so brittle it is almost impossible to cut them into gems. This brittleness is due to certain stresses in the rough mineral and it can only be removed by releasing the stresses and properly tempering the gem for cutting. A number of experiments were made in the writer's laboratory and results were very satisfactory. Heat was applied in the presence of water, the stresses were released and in most cases the color play was as vivid after the

treatment as it was before. Some specimens did, however, show a diminished play of color. Nevertheless, the procedure requires special apparatus and certain skill in order to prove successful. And the gems thus treated have a thin coating of milky white silica due to certain chemicals being placed in the water. The coating does not penetrate deep enough into the stone as to cause trouble and it is completely removed during the cutting and polishing process. The gem, having its color play preserved during the heat treatment and with its stresses relieved and then annealed, gives no trouble while being cut and polished.

The color play then, which we see in a beautiful opal, is apparently caused by the difference in the refractive index of the layers of strata or particles which make up the mass of the gem and these colors when once lost by desiccation seemingly can never be recalled. The reason for this is due, no doubt, to certain changes in the optical properties of the mineral. Though experiments have shown us many peculiarities of the opal there is still much more to learn concerning the gem. And still many corrections are to be made on the data which we already have obtained. Surely opal surpasses all other gems in its stand against an inquiry of science. It is little wonder then that in less enlightened ages many and various were the myths connected with the gem.

In the writings of the Latin philosopher, Pliny, we find mention of imitation opals which were so nearly like the genuine that it was difficult to distinguish between the two. However, in the present day, it is impossible to imitate opal so that even the novice could not distinguish the genuine from the artificial.

Opals are often altered and dyed to increase their value. Various methods are used to obtain a blackish or a bluish appearance in the stone. The writer has run across many of these altered gems, including opals which had been dyed in some organic solution, perhaps a saccharine solution, and then treated with aniline dye; or by soaking in a solution containing metallic salts and treated with an acid solution. Other specimens were mere doublets joined together with a colored cement. Opal doublets are easily distinguished from natural stones which have not been "doctored" as the film of colored cement is plainly discernable. There is also a difference between the upper and lower portion of the gem which can easily be noted. It is needless to say that such gems are not as valuable as those which are unaltered. However, it is the honest opinion of the writer that a gem which has been treated for the sole purpose of making it more durable or for preserving its beauty is just as valuable as a stone of equal grade which is not treated. A "doctored" stone is a poor gem made to appear as a good one.

Opal in the rough is often dyed and sold as black opal. The material selected for this type of altered stone is usually of the compact brown matrix variety which is often flecked with small patches of precious opal. The matrix being very porous easily soaks up some organic solution, as saccharine, and is then either dyed or charred with sulphuric acid. This renders the matrix black while the precious opal flakes stand out vividly against the black background. Some unscrupulous dealers moisten opal with oil or some compound containing oil or glycerine. This often tends to make an opal more brilliant while the film of compound lasts.

There are changes in color which may occur in an opal that has not been properly cured. And even those opals which have been properly cured, have been known to lose their brilliancy and never recover it. Sometimes dull and poorly colored opals have uncannily developed great brilliancy. This fact was brought home very forcibly to the writer some years ago when he sold a large opal-set brooch for the small sum of $25 because the opal was of a poor color and somewhat dull. Within a few weeks after the brooch was purchased, the customer returned and exhibited it. To the astonishment of the writer, the opal had developed into a most beautiful gem. The brooch has been constantly used for several years and today it has lost none of the brilliancy it so unexpectedly attained.

The writer would greatly appreciate notes and data collected by other experimenters on this gem and its reaction to various treatments applied.

The Opal

— *By* —

EUGENE W. BLANK

Scientific Editor, Rocks and Minerals

The opal has been known from the most ancient of times and the gem was highly regarded by both the Romans and the Greeks.

Pliny, one of the most voluminous writers of his day, has this to say of the opal: "Of all precious stones the opal is the most difficult to describe, since it combines in one gem the beauties of so many species, the burning fire of the carbuncle, the glorious purple of the amethyst, the green sea of the emerald, and the golden yellow of the topaz." Pliny ranked the opal next to the emerald and also relates how Mark Anthony exiled a rich senator, Monius, for the sake of a large opal.

Onomacritus writing 500 B. C. says: "The delicate color and tenderness of the opal remind me of a loving and beautiful child."

The black opal, a very rare variety of the gem, has been aptly described: "It combines the iridescence of the dewdrop with the color of the rainbow, set in the blackness of the night. It is a smothered mass of hidden fire." And at the grave risk of tiring my reader I will add the words of Ruskin in his lecture on Color. "The opal, when pure and uncut in its native rock," he says, "presents the most lovely colors that can be seen in the world, except those of clouds."

As a mineral opal is relatively common and any amateur collector can easily include several specimens of the cheaper varieties in his collection. Opal contains 3 to 13% of water, the more precious varieties usually ranging from 6 to 10%. The rest of the opal is mainly silica, SiO_2, and so opal is closely related to quartz, but differs from the latter physically in being softer and lighter. Also, it never crystallizes, always being amorphous. It is usually found in veins or irregular masses, sometimes with botryoidal, stalactitic, or earthy structure. Opal is a solidified jelly depending for its attractivenes and beauty upon a characteristic play of color, known as opalescence.

The opal is soluble in caustic potash and when mixed with sodium carbonate easily fusible. It is soft, 5.5 to 6 on Moh's scale, and consequently easily scratched. For this reason it is not usually classed with the precious stones. Opals when first mined are usually so soft they must be aged several months before cutting operations can be started. The opal is brittle and has a distinct chonchoidal fracture. The gem is usually very porous in structure and it is therefore unwise to immerse it in liquids. Normal opal is isotropic, but some specimens are double refracting, owing possibly to some internal strain. The specific gravity ranges from 2.10 to 2.20 and the refractive index from 1.444 to 1.464. Opal is often found as pseudomorphs after gypsum, glauberite, calcite and other minerals. Pseudomorphic aggregates are sometimes known as pineapple opal.

Pure opal, which is colorless, is rarely met with. It is usually clouded and stained dull colors by iron oxide, alumina, lime or magnesia. The coloration is not ordinary absorption since the transmitted light is complementary to the reflected. For example a blue stone held up to the light appears yellow in color. The opalescence of the opal is due to the fact that as the original silica gel solidified and cooled it shattered and subsequently, another gel containing a different amount of water and thereby differing in refractivity, filled up these numerous cracks. The resulting heterogeneity of the opal gives it a varying refractive index, and each crack has the same effect upon light as a soap-film. The thinner and more uniform the cracks the greater the play or color. In the variety known as harlequin opal the rainbow colors are flashed from little squares forming a fiery mosaic.

The opal has never been successfully imitated despite numerous attempts. Re-

cently milk opal has been colored by oils and pigments to imitate the rare red and blue varieties. The colors are fixed with Canada balsam. Black opals have been made by soaking ordinary opals in oil and then igniting the oil. The brilliancy of the stone is increased but the treatment leaves the opal fragile and increasingly prone to lose color.

Several syntheses of opal occur in the chemical literature. Coatings of material like opal have been noted in glass flasks containing hydrofluosilicic acid that had not been opened for several years. Opal has likewise been obtained by the slow cooling of a solution of silicic acid in water. These experiments are, for the present at least, of mere academic interest.

The principal varieties of opal include:

(1) Precious or noble opal.
(2) Fire or girasol opal.
(3) Common opal.
(4) Wood-opal.
(5) Hydrophane.
(6) Hyalite.
(7) Cacholong.
(8) Jasper-opal.
(9) Geyserite.
(10) Tripolite.

Precious opal is yellowish white, dark gray, or bluish in color. The lighter hued specimens are known as white opals, while the gray and blue opals are designated as black opals. Really black opals, in which the background is a true black, are extremely rare and consequently valuable.

Orange or yellow stones which exhibit opalescence are known as fire opals.

Common opal is translucent to opaque and shows numerous hues. When milk-white, yellowish, bluish, or greenish it is called milk opal. With a resinous luster and yellow in color it is resin opal. Wood petrified by opaline material is wood opal. In some specimens the siliceous water has taken away the wood and replaced it with opal with such dilicacy that the structure of the wood is perfectly retained.

Hyalite opal is a colorless and transparent variety that resembles crudely melted glass.

Cacholong is a porous variety which has a luster like mother-of-pearl.

Hydrophane is a light colored opaque variety of opal that becomes transparent and exhibits an opalescence when immersed in water. The older mineralogists, considering this stone nothing short of marvelous, named it "Oculus Mundi", the Eye of the World.

A curious variety of opal is tabasheer, a silica deposited within the joints of bamboo. It is porous, and, like hydrophane, becomes transparent when immersed in water. Menilite is a concretionary form of opal.

Jasper opal is red, reddish brown, or yellow-brown in color and closely resembles ordinary jasper.

The silica deposited by nearly all natural hot waters is opalescent. The Yellowstone Park geysers have built up large cones and extensive basins by the constant accretion of silica deposited by the cooling waters. This variety of opal is known as geyserite.

Tripolite, Diatomaceous, or Infusorial Earth is the porous, earthy and chalk-like deposits of the siliceous remains of diatoms and radiolaria.

Only three varieties of opal are recognized commercially, namely; the oriental opal, the fire opal, and common opal. The term oriental was given to the opal obtained in Hungary and carried to the East by the Greek and Turkish merchants. Apparent psychology already played a role in the business world for the term oriental imparted additional value to the gem. Opal obtained from the Orient was considered vastly superior to that from other quarters. It is interesting to know, however, that there are no known localities in the Orient where opals are found.

The value of an opal depends on various factors. The color should be solid, that is, it should not alternate with streaks or patches of inferior quality. Pattern is likewise to be considered. Where the grain is very small it is known as pin fire; when the color is in small squares, the more regular the better, it is known as harlequin; and finally we have the variety known as flash-fire or flash opal when the color shows as a single flash.

The harlequin pattern is the most uncommon and the most beautiful. When the squares of color are regular and show as distinct red, blue, yellow and green checkers this kind of opal is truly magnificent. It is extremely difficult to obtain separate pieces of opal of absolute similarity of color and pattern. Consequently for large pieces of jewelry, a single large specimen from which the whole can be cut, is worth much more

than many smaller stones. The harder the opal is the better, for it is less likely to lose its polish. Opals are generally cut en cabochon, either steep or flat. If they are regarded as being too thin and brittle for this, they are used for inlay work, and if scattered in small pieces throughout the matrix they are sold as such, under the name "root of opal". Fire opal is sometimes facetted.

For a long period Hungary[1] was the chief locality from which precious opal was taken, being found in the Tokai Esperieser Mountains, not far from Cserwenitsa, near Kashau. From the mines in this district the early Romans probably procured their supply of the precious stone. The opals from this locality are generally quite small and have been unable to compete with those found in more favored localities. It is claimed for the Hungarian opals that they are less liable to deteriorate than any others. This claim is open to question. The opals occur in an eruptive rock of andesite that is considerably decomposed.

It is to Queensland and New South Wales that the world is now chiefly indebted for its supplies of opal. The opals are found in the western interior of Queensland, at detached localities between Eromanga or Opalopolis, on the river Bulloo, in the extreme southwestern corner of the state, to Fenny or Opal Town, near Winton, almost in the center of the territory. These deposits were first located in 1890.

The mining is done by shafts through the desert sandstone, opal being found in a band of pipe-clay that varies from six inches to two feet in thickness. The gem is found in small ironstone nodules thickly imbedded in the pipe-clay.

In New South Wales the richest deposits are at White Cliffs in Yungnulgra County. These deposits were accidently stumbled upon by a hunter tracking a wounded kangaroo. The matrix is a Cretaceous sandstone and the opal occurs in seams, filling cavities in the rocks, or replacing wood, saurian bones and crystallized glauberite. Shells and bones are found entirely altered to precious opal making specimens of great beauty.

[1]Editor's Note:—Dr. Spencer, in his article "Opals in the Mineralogical Collection of the British Museum," which appears on page 14, states that the political boundaries of Hungary have been altered and that the opal locality is now in Czechoslovakia.

The opals from Mexico are mostly of the fire opal variety. They are mined in a number of the states, the oldest mines being in the State of Hidalgo, near Zimapan, where the opal occurs in a red trachyte. At the present time most of the opals are from the State of Queretaro, where mining operations are conducted on an extensive scale. The opal occurs in long veins in a porphyritic trachyte.

Opals are also found in Honduras but rarely reach the foreign markets. The mines, not extensively worked, are found in the western part of Honduras, in the Department of Gracias, and in the mountains on the boundary between Honduras and San Salvador.

Precious opals have been found in Hosako, Japan, which are nearly colorless and transparent with a bluish tint, and which show a change rather than a play of color, from emerald green to red.

Common opal is found in Bohemia, Iceland, Scotland and the Hebrides. Hyalite occurs in small quantity at several places in New York, New Jersey, North Carolina, Georgia, and Florida. Common opal has been found at Cornwall, Pa., and in Calaveras County, California. Gem Opal has lately been discovered in Humboldt and Lander Counties, Nevada.

Infusorial Earth is a most important member of the opal family chiefly because of its several industrial uses. It is employed in the manufacture of cements and polishing powder and as the "body", which, saturated with nitroglycerine forms the familiar dynamite of commerce.

The ancients regarded opal as the perfection of beauty. Later, in the 16th century, it was thought to increase the keenness of sight, to shield from suicide and to make its wearer a general favorite. It was held in high repute for treating diseases of the eye. It was variously believed to stimulate the heart, cheer the melancholy, and preserve from sickness. Its color was believed to wax and wane as the health of its wearer. Above all it symbolized hope.

More recently the superstition that the stone is decided unlucky has become rather prevalent. The cause of this has been attributed to Walter Scott's novel, "Anne of Geierstein". The late Queen Victoria demonstrated in many ways her love for the stone and chiefly due to her influence the opal is gradually coming back into the popular favor it justly merits.

Diatomaceous Earth--Its Nature, Occurrence and Use

—*By*—

JOHN MELHASE

Diatomaceous earth is a material of wide geographical distribution. It is known by many different names, such as desmid earth, infusorial earth, radiolarian earth, white peat, molucca, tellurine, randanite, ceyssatite, polirschiefer, bergmehl, kieselguhr, fossil flour, and diatomite; by the trade names of "Sil-o-cel", "Filter-cel", "Tri-o-lite", etc., and frequently, though erroneously, as tripoli.

In its purer state, diatomaceous earth is composed entirely of the microscopic fossil cell walls, or frustules of unicellular vegetable organisms or plants called diatoms and which, next to bacteria, are the smallest living plants known. Diatoms exist in incalculable numbers in the waters of the seas, in lakes and streams, in moist soil, and even in the atmosphere. Ordinarily they are too small to be seen without a high power microscope, although some giant species are just visible to the naked eye. These minute plants secrete about themselves a protective skeleton or box which may be shaped like a disc, triangle, spindle or tube. Beautifully ornate are these tiny boxes, ornamented by the most exquisite tracery of bars and beads imaginable, and each and every one is cast of transparent, opalescent silica by the master craftsman that dwelt within. Over ten thousand different varieties of diatoms have been observed and of this huge number less than a dozen are not ornamented and it is quite appropriate that they should be termed the "jewels of the plant world".

The beautiful opaline homes which housed the diatoms during their brief period of life served also as burial caskets for them when, in death, they sank to the bottom of sea or lake and there slowly and gradually built up the extensive beds of diatomaceous earth as we find them to-day. It is estimated that a cubic inch of diatomaceous earth contains the shells of 40,000,000 diatoms, yet the deposits of this material cover many square miles and in some localities reach a thickness of about 2,000 feet. The diatom, however, is a most prolific organism and a single individual will, in the course of about four weeks, have some 9,000,000 descendants. So-called "epidemics" of diatoms may be seen every year along Copalis Beach near Grays Harbor, Washington. These occur in April or May, following heavy rains, and at such times the beach for many miles will be covered with diatoms (*Aulacodiscus kittoni*) to a depth of four to six inches.

The physical properties of diatomaceous earth usually serve as a ready means for its identification. It is generally white or grey in color, finely granular and porous, loosely coherent to compact, with a hardness of 1 to 1.5. Its true specific gravity is 2.1 to 2.2; while the apparent specific gravity of dry blocks of pure material averages about 0.45. It is lighter than most of the substances with which it might be confused and floats in water until it becomes saturated. It is insoluble in all acids except hydrofluoric, but is readily decomposed by alkalis. Its non-effervescence in acid serves to distinguish it from marl or chalk; it has not the soapy feel of talc, nor the gritty character of most volcanic ash. It may, however, be mistaken for some of the finer grained varieties of volcanic ash with which it is frequently associated. The microscope can be relied on to furnish an infallible means of identification as the beaded fragments of diatom frustules can be mistaken for nothing else. In the field we may find beds of pure massive diatomite intercalated with volcanic ash, bentonite, sands, and shales. The shales themselves may be composed chiefly of diatomaceous material which, in turn, may alter to opaline shale, opal silica, porcelainous shale, or chalcedony. In color, these alteration

products range from colorless to jet black and they may be transparent to opaque, depending upon the amount of carbonaceous material contained.

The chemical composition of diatomaceous earth is $H_2O+nSiO_2$, the same as that of opal which contains 90 to 98 per cent. of silica and 2 to 10 per cent. of chemically combined water. Pure Diatomaceous earth contains 96 per cent. silica and 4 per cent. combined water, but in nature there is always more or less clay and foreign matter mixed with it. The purest deposits run from 86 to 88 per cent. silica, but for average commercial uses a minimum of 80 per cent. is considered quite satisfactory. An average of eight analyses from as many different commercial deposits shows the following constituents:

Silica	(SiO_2)	81.68%
Alumina	(Al_2O_3)	5.50
Iron oxide	(Fe_2O_3)	1.37
Lime	(CaO)	0.97
Magnesia	(MgO)	0.38
Potash	(K_2O)	1.14
Soda	(Na_2O)	0.20
Water	(H_2O)	8.31
	Total	99.65

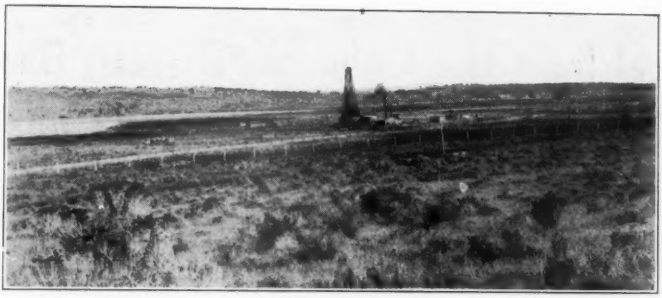
Diatomaceous earth deposits fall into two general classes; marine, and fresh water. The former were laid down in the sea and occupy areas near our present coasts; the latter were deposited in lakes and landlocked basins further inland. The fresh water deposits are generally the younger, ranging from late Tertiary to Recent in the geologic time scale; while the marine deposits occur chiefly in Miocene or older strata. The oldest marine deposits of which we have definite knowledge occur in the Moreno formation of California and are of upper Cretaceous age. Deposits of Triassic age are reported to occur in Russia, but this is not yet verified.

Like bentonite, diatomaceous earth is found in practically every country on the face of the globe. It is produced in Algeria, Australia, Barbados, Canada, Denmark, France, Germany, Hungary, Italy, Ireland, Japan, Java, Norway, Portugal, Russia, Spain, Sweden, and the United States. The world's annual consumption is about 200,000 tons, at least half of which is produced by the United States whose principal deposits occur in the States of California, Florida, Massachusetts, Maine, Maryland, Nebraska, Nevada, New Hampshire, New Mexico, New Jersey, New York, Oregon, Utah, Virginia, and Washington. About 90 per cent. of the total production of the United States is obtained in California, chiefly from the huge deposits at Lompoc, Santa Barbara County.

The Lompoc deposit is part of an almost continuous belt of diatomaceous earth that extends along the coast from San Diego to a point about 100 miles north of San Francisco. It attains its maximum development near Lompoc where a thickness of about 2,000 feet is obtained. This entire deposit is of marine origin and constitutes a large part of the Monterey formation of Miocene age. The diatoms which characterize this vast deposit are chiefly the circular, dotted *Coscino-discus*, with a lesser percentage of rod-like forms which resemble *Synedra*.

The deposits at Carlin, Nevada, are typical of the fresh water class, which are not so thick nor extensive as the marine depositions. They occur about the rims or on the floors of the old lake basins, now dry, and are frequently interbedded with sheets of lava, strata of volcanic ash, and tuff. The diatoms of these deposits belong to the genus *Melosira*, the Carlin deposits consisting of 100 per cent. *M.granulata*, which resemble straight, hollow glass tubes joined end to end and ornamented with numerous symmetrical rows of beads upon the cell-walls. Deposits near Lovelock, Nevada, consist of varying proportions of *M. granulata* and *M. distana*, the latter being ornamented like *M.granulata*, but smaller and more disc-like in outline.

Near Terrebonne, Oregon, on the Deschutes River, occurs a similar deposit of diatomaceous earth which runs 86 to 88 per cent. silica and 5 to 7 per cent. water. The beds are 30 feet thick and are surrounded and underlain by flows of lava. Several species of well preserved diatoms are found in this deposit, most noteworthy of which is the giant *Melosira arenaria*, a diatom so large that it is visible to the naked eye and which constitutes 100 per cent. of the lower 18 inches of this deposit. In eastern Oregon, notably in Klamath and Lake Counties, are many lava-bound basins, either entirely dry or containing but shrunken remnants of the lakes they once enclosed and in which diatoms once flourished in prodigious numbers. To-day these basins



Scene near Bonanza, eastern Oregon, showing typical basin in which deposits of diatomaceous earth occur.

are all rimmed about or floored with deposits of diatomaceous earth, some of excellent quality, but most of it containing a high percentage of volcanic ash and other impurities.

In mining diatomaceous earth, the overburden is first removed by means of scrapers or steam shovels, after which the deposits are worked as open quarries. At Lompoc, however, underground mining is also conducted in developing certain portions of the deposit. Most of the quarrying is done by hand, although channeling and undercutting machines are sometimes employed. The material is taken out in large blocks which are first air dried and then hauled to the mill where they are sawed into bricks and building blocks. Fragments and saw cuttings are ground and air sized into several grades of powder. Some of the finer powders, mixed with other ingredients, is made into refractory cement; while very fine dust is combined with clay to make tile, light weight brick, etc. Most of the diatomaceous earth is shipped as finished or semi-finished products; rarely in crude form. No standard specifications are in general use, but for brick and building blocks the material must be firm enough to be sawed and strong enough to sustain considerable weight. For ceramic purposes it must be free from impurities, especially iron compounds, and if used for filtering, the shape and size of the diatoms becomes an important factor. In general, the physical properties of diatomaceous earth are more vital than chemical composition.

Diatomaceous earth has many uses. For heat and sound insulation it has few, if any, equals and it also possesses the most desirable quality of being absolutely fireproof. Its melting point ranges from 1610 to 1750 degrees Centigrade and it has a thermal conductivity, in gram-calorie-seconds, of 0.000227 at 200°C. to 0.000313 at 800°C. when in dried blocks of 0.53 apparent density. For loosely packed earth of 0.12 apparent density the thermal conductivity is only 0.000127 and 0.000297 respectively, at the same temperatures. Used as an absorbent, it will take up from 150% to 200% of its weight in water without increase in volume; hence it is widely used as a carrier of liquid disinfectants. It is extensively used as a filtering agent for sugar syrups, fruit juices, oils, etc., and in removing bacteria from liquids. It is used as a filler in rubber, Portland cement, phonograph records, papier mache, sealing wax, magnesite flooring, wall-board, insecticides, etc.; also as a mild abrasive in hand soaps, cleaning compounds, and metal polishes; in dental powders and as a friction agent on safety matches and match boxes. It is extensively used in concrete work and as structural material. In the ceramic arts it furnishes the silica needed for body and glaze; while in the chemical industry it is used to manufacture sodium silicate or waterglass, fireworks, ultramarine, and as a base for the fixation of aniline and alizarin colors for pigments. Mixed with tallow or hard grease, it is molded into grease sticks for use on buffing wheels, and some of the colloidal varieties of diatomaceous earth are used in place of fuller's earth for bleaching purposes.

Current prices for diatomaceous earth, per ton f.o.b Nevada points are as follows: Crude, dried, in bags, $10; minus 40 mesh, $15; 300 mesh, $20; high temperature insulation, $30.

Opal from the Columbia Plateau Basalt Flows of Washington, Idaho and Oregon

— *By* —

C. O. FERNQUIST AND DR. H. C. DAKE

In the Pacific northwest states extensive geological changes took place in the Miocene period; a great uplift formed the Cascade mountains in the western part of Washington and Oregon. To the east of the main mountain upheaval, stresses were brought to bear which opened a large number of deep and extensive fissures on the surface of the earth through which enormous amounts of lava poured out. These lavas which are known as the Columbia river lavas are very thick in places and cover some 250,000 square miles in eastern Washington, Oregon, and parts of Idaho, Nevada, and California.

Opal has been found at many localities in the Columbia River lavas, and occurs in a wide range of varities. Common opal is represented to the greatest extent, but fire opal and precious opal are also found. The opal of the Columbia River lavas was used by the early Indians of the northwestern states, for arrow and spear points; some very attractive specimens of this kind have been found.

WASHINGTON

City of Spokane.

In the city quarry at the corner of 29th Ave., common opal of yellow and green color has been found in the basalt. Associated minerals are sphaerosiderite, aragonite, and chloropal.

While a water ditch was being excavated in the southeastern section of the city, common yellow opal, pierced by aragonite crystals, was found.

At the corner of Sprague Ave. and Division St., transparent clear hyaline opal is found associated with sphaerosiderite and cristobalite. Along the river banks near St. Luke's hospital, very good opalized wood is sometimes found.

Deep Creek Canyon.

About eight miles northwest of Spokane at Deep Creek Canyon, along the contact of the basalt and the shale of the Latah Formation, clear botryoidal hyaline and black iron opal is found. The iron opal is an unusual type of apolization being formed and colored by ferric iron in the presence of oxygen. Some of these specimens contain rosettes of aragonite crystals coated with hyaline opal.

Belmont, Washington.

At this locality is a rock quarry where yellow jasp-opal is found and a dark grey to black opalized wood.

Peach, Washington.

Near this town and along the Columbia river there is a large opalized tree imbedded within the Basalt. Hyaline opal is also found here.

Mandove, Washington.

Near this town is a low hill composed of a very hard and highly vesicular basalt, most of the vesicles being filled with an opaque hyaline opal. A small amount of this opal is of the precious variety and by breaking open more or less of the rock a limited amount of precious opal can generally be obtained. A few very fine blue colored opals have also been found at this locality.

Waterville, Washington.

Common green opal is found at this locality and specimens from this region can be seen at the Field Museum in Chicago and at the Los Angeles Museum.

Quincy, Washington.

At this locality is a deposit of diatomaceous earth in which large concretions of a brown opal are found. A very large specimen from this locality can be seen in the Spokane, Washington, museum.

Vantage Ferry, Washington.

Near the Columbia river bridge at this locality is an abundance of opalized wood in a large variety of colors.

Lind, Washington.

In a rock quarry near here there is an occurence of a white porcelain-like opal. This opal is often seen in very interesting forms and shapes many of which have the appearance of aragonite and are sometimes coated with fine hyaline opal. Specimens from this locality can be seen at the Spokane museum.

Connell, Washington.

In a road cut near here an abundance of white hyaline opal of a botryoidal form is available in the basalt.

Malton, Washington.

Near this town common opal occurs in a great variety of colors and is abundant.

Whelan, Washington and Moscow, Idaho.

While digging a well in 1890, near Whelan, which is near the Washington and Idaho boundry line, fine precious opals were found in the basalt. Mining was immediately started and in 1891 the production was over $5000.00. Some very fine opals were found here, one gem of 3½ carats was valued at $500.00, while another mass weighing about two ounces was held at $1200.00. The deposits were worked mainly on the Washington side but some work was also done on the Idaho side. There is no record of any work or production after 1894.

IDAHO

Salmon river, Latah county, Idaho.

Some of the finest opal ever produced on the American continent, comes from this locality. The opal occurs here as nodules in a very hard trachyte rock, as a matrix, so the material can be readily and safely cut into gems. One small nodule of opal from this locality was sold for $1000.00 and many other valuable pieces have been found. This locality is undoubtedly worthy of further exploration.

Kendrick, Idaho.

Specimens of dark grey opalized wood are found here.

Boise County, Idaho.

Sandstone cemented by fire opal occurs in the Tertiary lake beds on Moore Creek at Idaho City.

Custer County, Idaho.

The copper silicate ores of the Mackay district contain abundant but very small grains of fire opal.

Kootenai County, Idaho.

Large size specimens of common opal occur at Setters, in a large variety of colors and translucency. Some of the red opal here can probably be classed as a "fire" opal. The opal at this locality occurs in a light grey altered basalt. Several shallow pits have been dug along the edge of a cliff, at Setters, above the railroad tracks. Fine specimens from this locality can be seen at the Spokane museum.

Lemhi County, Idaho.

Opals are found on Panther creek at an elevation of 7000 feet. They occur here in a porphyry dyke, having a width of about 150 feet, the rock being full of opal in a variety of colors and kinds. Milky, blue, green, brown, pink, white and some transparent fire and precious opal are available here. Many of the better opals are of fairly large size but being brittle and the matrix rock quite hard, it is difficult to secure large unbroken specimens. One opal of sixty carats, with green reflections and one brown one of 150 carats have been obtained here, although most of them seldom weigh over ten carats, after being removed from the matrix. This locality also furnishes a peculiar glassy opal with a broad flame of colors.

Lincoln County, Idaho.

On Clover Creek, very fine, well preserved opalized wood is found. The main colors are buff, yellow, and black. The grain and structure of the wood is preserved perfectly.

Owyhee County, Idaho.

In Owyhee County in the Snake river canyon and near Enterprise some very fine quality precious opal has been mined. Near Enterprise a number of the old workings can still be seen. In view of the fine quality of opal which was removed in the past and the small amount of work which was done it would seem this region could be prospected with profit. E. V. Shannon in his very excellent work: **"Minerals of Idaho"** gives an excellent description of this locality.

OREGON

Malheur County, Oregon.

Along Sucker creek from the region of Homedale upstream to Rockville some very excellent opalized wood has been found. Much of this material occurs in large pieces and is suitable for cutting into specimens. Large amounts of fine agate are also found on Sucker Creek. The well known locality of Enterprise in Idaho is very near Sucker Creek, hence they are doubtless of the same geological age.

Baker County, Oregon.

Opal is very common in the basalts of this county, being found at numerous localities. At Pleasant Valley some excellent banded, white and black, opalized wood is found.

Near Durkee there is a locality where precious opal has been mined in a small way, but no extensive work has been undertaken, although the opal is of good quality for gem cutting.

On Shirt Tail Creek at the Oregon "Jade" mines, common opal in yellow, green and brown colors is mined with the "jade". The prase and plasma mined here is very good and makes an excellent substitute for jade. At the mines here the opal occurs in a hard basalt rock in association with jasper, chalcedony, calcite, sphaerosiderite and the following zeolites; mesolite, thomsonite, heulandite and phillipsite.

Near the town of Baker, Oregon, small amounts of opal are mined from time to time, some of which are of very good quality, but the quantity produced is small. The opal is found only in small "pockets" and usually encountered in an accidental manner.

Hepner, Oregon.

Spherical nodules of a blue variety of opal are found near this locality, some of which are very attractive when cut and polished for specimens.

John Day River Canyon, Oregon.

Common opal is found here at many different places and in time past small amounts of fire opal have been taken from this region.

Opal Springs, Oregon.

This locality is very unique in that the opal is found loose in small nodules at the mouth of a large spring. The opal occurs here in the basalt and is brought to the surface by the water as the opal nodules are erroded from the rock. Very little fire opal is found here most of the material being an opaque hyaline opal. This occurrence has been described previously in ROCKS AND MINERALS[1].

Antelope, Oregon.

Common opal and hyaline opal are plentiful at this locality, occurring with the large amounts of chalcedony and jasper found here.

Deschutes River Canyon, Oregon.

In the basalt flows of this deep river canyon common opal and fire opal are sometimes found, occurring usually as nodules in the vesicular basalt. At the time of the construction of the railroads in the Deschutes canyon, small amounts of precious opal were uncovered at widely separated places.

[1]A Unique Mineral Locality in Oregon. By Dr. Henry C. Dake. ROCKS AND MINERALS. March, 1928. Vol. 3, No. 1, p. 19.

THANK YOU

The Editor takes this opportunity in expressing his sincere appreciation of cards and other remembrances sent him for Christmas, by many subscribers to and friends of ROCKS AND MINERALS. May the many good wishes extended him and to the magazine be returned the senders an hundred fold.

Prospecting for Opal*

Opal is a soft, non-crystalline gem consisting mainly of silica. No opal exceeds the beauty of those from the States of New South Wales, Queensland, and South Australia, Commonwealth of Australia, particularly the black ones. In that country the opal occurs in sandstone in dry desert areas. Opal ground does not resemble gold-bearing material; there is no gravel, sand, or loam in it. Opal prospectors don't pan in creeks and gullies; the opal generally occurs under the sandstone roof, not on the bottom as gold or tin. In sandstone country study the ground carefully. A small black or gray material like a stone should be struck with a pick or hammer; if it cracks or breaks like coarse glass it is probably "potch" or young, false, or worthless opal. But examine it for "color" as it may have a faint flash of red, green, or orange in it that weathering has not quite destroyed. This potch is sometimes exposed on the sides of ridges, and under the sandstone cap may be a layer of "opal dirt". Potch may be black, gray, white, milky, blue, green or glassy; and so may opal. Rain and wind may have moved some of this opal and deposited it a little farther down the hill. Farther yet there may be another "level", hidden by loam and grass, and perhaps ironstone pebbles. The White Cliffs opal field of New South Wales was found by such observation.

Opal mining is a small-scale operation; large companies could not make it pay. Shallow shafts are sunk here and there to 4 to 40 feet depth, but more often to 14 feet. Sinking is fairly easy. Bottom means breaking through the last of the sandstone into the opal dirt. At this point the sandstone is hard and this layer, also a foot or more of the "roof" under it have yielded much opal.

Many claims don't have this hard layer. If a shaft does not show potch or color, sink deeper through the opal dirt and then drift either direction from the shaft. The ground is easy to dig, but care is necessary so that the pick does not split or chip an opal. Potch and color are indications of close proximity to "precious" opal and should be followed. A "pocket" or cluster of "nobbies" or stones may be found. When near opal, dig carefully with pick, knife, or candle holder. Generally, sandstone makes a good roof, but if a large chamber is dug, a prop gives security. Some miners leave pillars as supports and gouge them out on retreating and abandoning claims.

Opals are sold to experienced buyers in the field as " rough" or "faced". The former are unfaced stones, with just a "snip" taken here and there around the edge. To face a stone, many opal miners have a foot-power carborundum wheel and a felt wheel with jeweler's rouge to clean off the dirt and potch and bring out the "pattern". Water is used for this operation. This job must be done with care so that the stone is not blurred or the pattern spoiled. A grain of sandstone in the opal can not be ground out, nor can a "cloud" or film.

In Queensland, the stones occur as "boulder opal" in an ironstone band a foot thick under the sandstone. The band may be of small ironstone pebbles or cobbles, inside of which may be "kernels" of opal. Great care is required in breaking the cobbles and not damage the stones. In other fields the opal occurs as seams in sandstone boulders encased in a soft shell of coarse sandstone, or as a "pipe" running through sandstone, or in vesicular basalt.

In South Australia, the precious opal occurs as bands formed in potch. Hand augers are a quick and easy method of prospecting to the opal dirt. Chips of opal show in the sludge.

In the United States, opal deposits are associated with petrified wood in beds of volcanic ash in desert country, near the Nevada-Oregon line; also in northeastern Washington; in Mitchell County, N. C.; near Fort Bayard, N. Mex.; in Owhyee County, Idaho; east of Johannesburg, Calif.; and in San Bernardino County, Calif.; along the Deschutes River, Crook County, Ore.; and near Alpine, Texas. The American production of opal is irregular—from none to $15,000 a year, but a low average.

*Excerpts from *Prospecting for Gold*, by I. L. Idriess, 3rd ed., 1932; Angus & Robertson, Sydney, Australia, and from *Opals* by I. Aitkens, Information Circular 6493, United States Bureau of Mines, September, 1931.

Opal Mining in Australia

—*By*—

P. ORMSBY LENNON

Royal Empire Society, London, England

In eastern Australia, precious opal occurs over an enormous belt of country, roughly 250 miles in width, extending from New South Wales half-way up Queensland. The former State is today Australia's main producer. Since the war, the industry in Queensland has been practically dead, and even before then, it had many ups and downs. The fact is attributable to the uncertainty of opal occurrences, and to the inhospitable nature of the country where the gem is found. For the most part the deposits are situated out in arid sand plains, often waterless, and covered with shadeless clumps of gidgee and mulga. At times, the heat is almost unbearable, and the "willie-willies" (cyclones) that rage across these sandy wastes, make the prospector's life a hard one. Experts are of the opinion that vast deposits still lie in Queensland, awaiting discovery. But until more systematic prospecting work is done and water supplies are adequate, the industry in the northern State will continue to languish.

Australian deposits occur in different formations. Some are found in sedimentary rocks of Cretaceous origin; others in vesicular basalt. The Desert Sandstone deposits are believed to be unique in the history of opal mining. In northern fields, the gem is known to occur in ironstone bands in seam formation; and also in sandstone boulders. In the latter, opal is usually encased in a sandstone shell.

Opals are of wide distribution throughout the Island Continent, except in Tasmania, where, so far, wood opal has only been found. There are deposits in Central, South and Western Australia, and at places in the Northern Territory. In passing, it may be mentioned that Australia is the world's only producer of black opals. This rare and beautiful gem comes solely from the famous field at Lightning Ridge, not far distant from the New South Wales-Queensland border.

At Lightning Ridge, the skyline is broken by low ridges and plateaux, which rise from "black soil" plains to heights of about 100 feet. These are usually blanketed with quartz and ironstone gravels and pebbles; while here and there occur conglomerate outcrops, and a hard secondary quartzite known locally as "Grey Billy". To its more weathered forms, the term "Shin-cracker" is applied. Both these quartzites occur in loose or continuous masses.

On the ridges and slopes, where there has been considerable weathering and erosion, a loose covering of gravel, soil and pebbles overlies a light and porous sandstone, the specific gravity of which is very low. It is said that a cubic yard of the material weighs no more than 15 cwt., and geologists are of the opinion that this is due to its silica having been attracted to the surface by capillary action.

Throughout this soft, porous, biscuit-like, underlying sandstone, black opal may be found at varying depths. Very often the shafts touch gem-bearing layers at 40 to 50 feet, but on ridge slopes these may be within a yard or two of the surface, perhaps even outcrop, or have been eroded away entirely.

There is seldom any surface indication to guide the "gouger", as the opal miner is called. Chance usually dictates the site of his future operations, as likewise chance rewards or penalizes him. More often than not, the spin of a penny or the swing of a pick determines where work is to be commenced. Judgment is of little assistance, so the green new-chum gouger stands as much chance as the dessicated old-timer. Therein lies the fascination and the heart-break of opal mining.

At Lightning Ridge the first or upper level is usually indicated by a thin hard layer of siliceous sandstone, known as the "Steel Band". Beneath is the "Opal

Dirt", a layer consisting of soft material like clay or clayey sand, seldom more than a yard thick. Sometimes, however, it may be very hard. In both these layers opal may or may not be found. If not, the gouger can sink deeper in the sandstone in the hopes of finding a second level with more opal dirt.

As a rule shafts are about 5x2½ feet in size, just enough to permit elbow-room. Wider shafts prove uneconomic, as they entail the shifting of extra mullock. When about nine feet down, the gouger then logs up and puts the windlass on. No timbering is necessary below.

Quantities of valuable gems have been won from the steel band, but by far, the bulk of plums and pot-boilers alike, have been gouged out of the opal dirt layer, from 6 inches to 1 foot down. The gouger proceeds with caution when he bottoms on these layers. They may prove a veritable jewelers' shops, and an unlucky stroke of his pick may smash a valuable gem to fragments.

Gems are gouged out with knives or small gouging picks, and sometimes with the "spider"—a steel spike or piece of twisted fencing wire constructed to hold the gouger's candle. This is jabbed in the sandstone by his side as he works.

The gouger, of course, may bottom on color or "potch". Potch is all the tints of the rainbow and valueless. It is opal a few million years too young. When on these embryo opals, the gouger then makes his drive, about a yard in width and a foot or so extra in height. Working back on the face, he keeps tunneling, rabbit-like, until the potch is "cut out" or he lights on a patch of gems.

The gems are known as "nobbies" or stones, and are coated with opal dirt. They may occur in a variety of ways—in clusters like grapes; spread about evenly; or in little colonies that adhere to the sandstone roof like barnacles on a ship's bottom. When dislodged, they are examined for a flash of color by the light of the candle, and perhaps gingerly chipped with the gouger's snippers, by way of preliminary test. But until "faced" (cut) there is no telling their approximate worth.

Some gougers sell their output in the rough, just snipping each gem enough to reveal good points. Selling this way is just as much of a gamble as gouging. A parcel sold in the rough may fetch £200, and when faced prove worth only half that. On the other hand it may be worth double or more. Facing a parcel, too, is a gamble. The process may bring to light such faults as poor color, "sandspits", "clouds", and "smokiness". It might have fetched a much better price in the rough.

Most men sell their gems ready faced, having their own carborundum wheels and accessories to execute the process; but on every field of importance are to be found professional cutters who do the work for a small charge, usually about 6d. per stone.

Another type of opal mining on "nobby" areas is the gentle art of "noodling". The noodler is usually a gouger who has "gone bust" from picking on a series of duffers. He scratches over old dumps, searching for stones that may have been overlooked, and sometimes large sums of money have been made at this occupation. The practice has one big disadvantage. Where the adjoining shaft has

Courtesy Commonwealth Immigration Office.

Street Scene, White Cliffs Opal Field, New South Wales.

been abandoned, the dump is often scratched back into it, piece-meal. Such shafts may therefore never be used again. The history of many supposedly worked-out claims and fields in Australia have proved that further levels of opal dirt often lie below the sandstone deeper down. It has happened again and again that deeper sinking has resulted in new and infinitely more valuable levels being brought to light, thus giving "dead" fields new life.

The famous black opals come almost exclusively from the Lightning Ridge field, but quantities of the light variety are also mined there. The latter is the sort gouged for on the White Cliffs field. Each of these classes are divisible into numerous grades, ranging from potch, worth a few pence to shillings an ounce, to high-quality gems worth many pounds a carat.

At White Cliffs, the opal is usually found in seams and veins between the bedding planes of the rock, and here fossil shells converted into precious opal are not uncommon.

In Queensland, precious opal occurs principally in the softer beds underlying a siliceous capping of limestone. "Boulder" and "sandstone" opals are the two chief types. The former is in a nodule or kernel of sandstone, found either in the clay beneath the overlying rock, or in the latter itself. Nodules are treated in a crude manner, and the wonder is that some enterprising prospector has not evolved a better method. A tomahawk is used to chip or break the top off. If the shell is blank it is thrown away, but if it contains noble opal, the pericarp of stone is broken off, giving a rich reward for labor involved. The drawback to this rough and ready method is that valuable gems are liable to be smashed during extraction.

On the other hand, the sandstone opal is found in a band of clayey substance, just below the overburden, and is easily detached from the soft casing enveloping it. Occasionally traces of the gem are found on the surface, and lucky indeed is the gouger who "specks" color or potch in this way. Such indications, though sometimes deceptive, will often save him "sinking on the Blind."

Occurrences of Opal in California

—*By*—

W. SCOTT LEWIS

While precious opal of commercial value has not been found in California in sufficient quantity to warrant mining operations many other interesting forms are fairly common in various localities.

The first discovery of opal in the state, as far as known, was made in 1886 near Mokelumne Hill, Calaveras County. The pieces were found loose in a stratum of gravel, 345 feet below the surface. They were white and about the size of a walnut but devoid of fire.

In 1895 opals were found at the chrysoprase locality near Visalia. They were beautiful, although lacking fire. Some were yellow, resembling amber, while others were green.

In 1897 fire opals were found near Dunsmuir in the northern part of the state. They were small but of good quality.

Hyalite, the transparent variety of opal,, has been found in Lake County, north of San Francisco. It also occurs associated with semiopal in the Diablo Range.

Different forms of opal are found in many places on the Mohave Desert, the occurrences appearing to be of a quite similar character. In each instance the opal occurs in seams, veins and pockets in lava, decomposed lava or tuff of Tertiary age. As far as the writer has been able to observe each locality is associated with rhyolite, evidently a surface flow as shown by the presence of bubble holes or a shaly structure presumably due to motion while in a scarcely molten condition.

The only locality where mining operations have been carried on to any extent is situated in San Bernardino County about 25 miles northwest of Barstow,

Here the opal occurs in a very hard clay that is doubtless decomposed igneous rock. Some of the opals are almost amber-yellow while a very few can be classed as precious or fire opals. "Semiopal" is common on the surface. It resembles genuine opal but does not have its beauty. The deposit, which has not proved of commercial value, is about half a mile wide and two miles long. It dips rather steeply and probably rests on granite. It is overlaid by tuff.

About 30 miles west of the Barstow locality is a group of volcanic hills that have produced much chalcedony of unusually fine cutting quality. This occurs in seams and pockets in rhyolite which in places shows a shaly structure. This locality was first visited by the writer in 1912 and at that time appears to have been unknown to prospectors as much valuable material could be had merely by picking it up. The largest specimen obtained weighed over fifteen pounds and was of cutting quality. This was perhaps the largest piece of true gem chalcedony ever found in the state. While examining the material a number of specimens were found in which white inclusions were scattered through a matrix of translucent chalcedony. These were polished and yielded stones of much beauty. At the request of the Geological Survey a number of pieces were sent to Washington where the inclusions were found to consist of white opal. This stone was later put on the market under the name of "frost-stone" and met with a ready sale. Some material is still being produced at this locality but most of it is only of value for specimen purposes.

Fire opal has recently been reported from a locality some miles north of the one just described. It is stated that the opals are very small and of no commercial value, but can be obtained by going over the surface of the ground with a garden rake. None of this material has yet been seen by the writer.

Both milk opal and "resin opal" have been found near Rosamond, Kern County, in the western part of the Mohave Desert. The resin opal, which is a translucent yellow, is found in a hard white tuff near a contact with red rhyolite. The milk opal is associated with chalcedony of an inferior quality.

Farther north in Mono County, where the desert begins to give way to forest, in a region of many hot springs, are deposits of opal that have been formed since the close of the Tertiary and are of quite different character from those discussed above. Near Casa Diablo are quantities of a very porous geyserite. This is a light-colored mineral except where stained bright red with hematite. A few miles southeast of Casa Diablo, at the "geysers", is a cliff coated with floatstone. This is so porous it resembles pumice in structure and large pieces float on water. Small pieces usually sink as the proportion of closed to open pores is less in a small piece.

Opalized wood is common in some parts of the state and specimens are often very handsome. Some of the finest comes from Nevada County, being found in ancient gold-bearing gravels, overlaid by a capping of lava. In some cases standing trees have been altered to translucent silica of various shades of brown, yellow and black. So perfect has been the change that Prof. Le Conte says in his **Elements of Geology** (Page 192): "Not only the external form of the trunk, not only the general structure of the stem—pith, wood and bark—not only the radiating silver-grain and the concentric rings of growth are discernible, but even the microscopic cellular structure of the wood and the exquisite sculpturings of the cell-walls themselves are perfectly preserved, so that the kind of wood may often be determined by the microscope with the utmost certainty, yet not one particle of the organic matter of the wood remains."

Diatomaceous earth of commercial quality is found in large quantity in many parts of California, the deposits sometimes being several thousand feet thick. They always occur in Tertiary sedimentary formations that were laid down under the sea. Diatoms are very minute single celled plants with a skeleton composed of opal and the number required to build up a large deposit is almost beyond comprehension. They are believed to have been the original source of the California oil as the oil fields bear a definite relation to diatomaceous shales.

The above sketch is not by any means complete, especially as regards the desert regions. The writer has observed traces of opal at many widely separated localities and it is possible that interesting discoveries may yet be made among the extensive Tertiary rhyolite flows that cover such a large part of that great region.

Opal in Peekskill, N. Y.

—*By*—

PETER ZODAC

Editor of Rocks and Minerals

Opal is a common mineral in and around Peekskill, but it occurs in a form so inconspicuous and as a coating on rock which often is so badly weathered as to literally fall to pieces when handled, that it is no wonder the mineral has not been noted before. At least no printed report has ever been called to the writer's attention. Since the summer of 1931, seventeen occurrences have been found and they will be briefly described in this article.

The variety of opal found here is the glassy hyalite. It is a secondary product, coating rocks in small botryoidal masses and thin crusts. Some specimens show a slender string-like form. On solid, clean rocks the color of hyalite is bluish-white when in thin crusts, and grayish-white to white when in thicker masses. Only in a few instances is the opal of the transparent, water-clear variety for which hyalite is especially noted. On weathered rocks, the color is brownish and yellowish, due to limonite stains. All the hyalites found so far are without "fire" and so are of no value as gems, but as the mineral is very common, gemmy material may still be found.

To the naked eye the coating is so unattractive that as one observer puts it: "It looks as if someone shook a wet paint brush, and small dabs of white paint spattered on the rocks." But under a magnifying glass the mineral shows up beautifully.

The first occurrence of opal in this vicinity was found in August, 1931, on the campus of the Peekskill Military Academy, when the campus was being graded. A pipe line stretching across the campus from Oak Hill Street to a fire hydrant at the Junior School was lowered two or three feet and some rock was blasted and excavated. Samples of the rocks were collected and on them were found the hyalite. The mineral occurs as small glassy crusts and yellowish botryoidal masses on mica schist. The locality is now completely buried and no more specimens can be collected.

The second occurrence was found on May 14, 1932, when on a reconnaissance with Messrs. Charles and George Dietz

Aug. 1932. *Photo by Fred W. Schmeltz.*

Looking north over the campus of the Peekskill Military Academy. The dotted line marks position of former trench. The writer, on the right extremity of the line, is standing over spot where opal was found. In the background are two of the many buildings of the Academy. This famous institution with an enviable record and which attracts students from all over the world is now celebrating its 100th anniversary—1833-1933.

to the Emery Mines at Toddville, about one mile east of Peekskill.[1] The opal occurs in glassy and in white crusts on gabbro at the Strang Emery Pit, the most northwestern pit in the district. The mineral is very common as many specimens were collected.

The third occurrence was found on June 29, 1932, on the athletic field in Depew Park, Peekskill. The field was being graded and considerable rock was blasted and excavated. The opal occurs as small glassy, brownish and whitish crusts and botryoidal masses on gabbro. A large part of the gabbro was disintegrated and fell to pieces when handled, but a number of good specimens were collected. Fair specimens of grayish-white hyalite coating gneiss were also found.

The fourth occurrence was found on August 20, 1932, at the old Crugers Emery Mine on Dutch Street, near Montrose, two miles south of Peekskill. Only one specimen was found, a grayish-white coating on gabbro, but others may be present. The writer paid only a brief visit to this locality, accompanied by Mr. Emmet Doherty of Peekskill and Mr. Henry Thurston and son David of Montrose.

The fifth occurrence was found the same day and by the same party. The locality is on Lower Washington Street, Peekskill, at Pole No. 120. An excavation in very contorted and weathered gabbro bordering the east side of the road yielded a fair specimen of hyalite.

On the same day, the same party and with Mr. Thurston in charge made a trip to the sixth locality on Maple Avenue, where interesting specimens of hyalite were found during the spring of 1932 by a party of three mineralogists of which Mr. Thurston was a member. The others of the party were Mr. J. C. Boyle of the Children's Museum, Brooklyn, N. Y., and Mr. William Vogt, Curator, New York State Bird Sanctuary at Jones Beach, L. I., N. Y. This occurrence is at the old Wilkins farm two miles southeast of Peekskill, and is on gabbro bordering Maple Avenue. It stretches for about four hundred feet, though the rock is not exposed for the entire distance. Two small rock-cuts about fifty feet west of the road and near the ends of the hyalite-bearing gabbro also yielded some nice specimens.

The seventh occurrence was found on September 7, 1932, in a small rock quarry on the property of Mr. James Hill which runs south off Crompond Road at Toddville. The locality is not far from the Strang Emery Pit. A trip was made to the Sapphire locality with Mr. Charles Travis of Peekskill and on our way back a few minutes were devoted in examining the above quarry. A nice specimen of grayish-white botryoidal hyalite on gabbro rewarded our examination.

The eighth occurrence was found on September 13, 1932, at the junction of Maple Avenue and Furnace Dock Road on the property of Mr. John B. Moore. A visit was made this section in company with Mr. Robert Taylor of Peekskill and Mr. Herbert Moore (son of Mr. John B. Moore) for the purpose of locating a garnet mine known to exist there. The trip was a failure as far as the garnet mine was concerned, but we were recompensed with a good specimen of grayish-white hyalite coating hornblende gneiss. The locality is about 2000 feet southeast of the Maple Avenue occurrence.

The ninth occurrence was found in the emery pits on the property of Mr. Mervin Lent, which is best reached from Croton Avenue about one mile southeast of Toddville. The locality was visited on September 26, 1932, with Mr. Charles Allison of Peekskill. A number of nice specimens of white and also glassy hyalite on emery were collected.

The tenth occurrence was found at the Anthony's Nose pyrrhotite mine about three miles north of Peekskill, on September 27, 1932. The writer and Mr. Travis have been making a special study of the mineral occurrences at this mine and a large number of minerals—many of which have never been reported—rewarded our efforts. One of these minerals is hyalite. A good specimen of clear, glassy, botryoidal hyalite on pink granite was found in a small proving hole which we have designated as No. 2 Pit. The granite specimen has one side polished (faulted) and the hyalite is near this face.

The eleventh occurrence was found on the same day and in an exposure of graphite schist which borders the east side of the Military Road. This road was built years ago and was to serve as an approach from the north to the National

[1]Sapphires near Peekskill, N. Y. By Peter Zodac. ROCKS AND MINERALS, Sept. 1932. Vol. 7, No. 3, p. 91.

Guard Encampment, now known as Camp Smith, but was never completed. The hyalite was found near Hemlock Springs, about 1200 feet south of the northern extremity of the road. The locality is about 500 feet west of the pyrrhotite mine. The hyalite occurs as white and yellowish botryoidal masses on graphite schist.

The twelfth occurrence was found on September 30, 1932, at McCoy's Gold Mine now on the property of Camp Smith. The mine is a vertical shaft, 8x10x22 feet and was sunk in a faulted zone in granite. The shaft originally was much deeper than 22 feet but has been filled in with leaves, rubbish and other material. A short visit only was paid the locality by the writer and Mr. Travis, but a number of interesting minerals including hyalite were collected. The hyalite occurs as clear glassy coatings on gray granite.

The thirteenth occurrence was found on October 2, 1932, at a small limestone quarry on the property of Mr. Stuyvesant Fish, near Annsville, about a mile north of Peekskill. Only one specimen of hyalite was found and it forms a white coating on a contact of milky quartz and gray limestone. Mr. Ramon Conover of Kyserike, N. Y., accompanied the writer on this trip.

The fourteenth occurrence was found on October 25, 1932, when in company with Mr. Travis a trip was made to the Crugers Point Park, about three miles south of Peekskill, with the hope of relocating the contact mentioned by Dana as producing staurolite and other crystals. In this we were unsuccessful though the area was thoroughly covered and all promising outcrops carefully examined. Minute gemmy crystals of almandite garnet were plentiful in the mica schist outcropping on the beaches and should make excellent micro-mounts. Aragonite, clinochlore, pyrite, rose quartz and hyalite were also collected. The hyalite is of fair quality and coats gabbro.

The fifteenth occurrence was found on November 15, 1932, by Mr. Travis, near the top of Blue Mountain about one mile south of Peekskill. One small specimen coating gabbro but of good quality was collected.

The sixteenth occurrence was found the same day on the extreme top of Spitzenberg Mountain, one mile further south. Only one specimen on gabbro and of poor quality was collected.

The seventeenth and last occurrence is the Croft magnetic iron mine which is about five miles north of Peekskill. A trip was made to this mine on Jan. 27, 1933, with Mr. Travis and his young cousin Billy. Among a number of minerals found which included graphite, titanite and xanthitane was a good specimen of hyalite coating epidote—garnet gneiss.

The first occurrence mentioned in this article was found in a section adjacent to the gabbro area known as the Cortlandt Series, and close to the contact of gabbro-mica schist. The contact is concealed by heavy drift but is not over two hundred feet south from the hyalite occurrence on the Academy's campus. The next eight and three of the last four occurrences are all in the gabbro area. The others are all north and at some distance from the gabbro area and therefore are of special interest.

These occurrences prove that hyalite is a common mineral found around Peekskill. Fifteen of the seventeen occurrences mentioned were found since June 29th of the past year. The number of occurrences may easily be doubled or even tripled, as it is the writer's belief that every fair-sized exposure of weathered rock, and especially gabbro, will yield hyalite. This has been verified in at least a dozen instances at the emery mines which have been listed as only two occurrences. The best field for hyalite is the emery locality where the mineral is very common.

Four other localities are known but as they are some distance away from the city, they were not included in the above listing. They are all along the Seven Mile Road which runs approximately east and west about ten miles north of Peekskill. The occurences were all noted on October 27, 1932, when a trip was paid the district accompanied by Mr. Travis in search of a lodestone[2] occurrence reported by Miss Helen Wright of Castle Point, N. Y. The lodestone occurrence was easily found and in addition a large deposit of titanite[3] was also recorded from the Fahnstock Memorial Park. A few good specimens of hyalite

[2] and [3] Notes and News Items from Peekskill, N. Y. ROCKS AND MINERALS, Dec. 1932, Vol. 7, No. 4, p. 148.

coating magnetite gneiss were picked up from the loose material bordering the south side of the road at the culvert about 100 feet west of the drive into the park. About two miles west of the park many fair specimens of hyalite on gneiss are to be found in the loose material bordering both sides of the road and a similar occurrence was found a mile further west. And a half mile further in a cut which borders the north side of the road, hyalite is very common and good specimens coating granite and mica schist were collected including a fair specimen coating microcline. The road terminates at the Albany Post Road 2.3 miles west of the cut.

The writer takes pleasure in extending his grateful thanks to Messrs. Charles and George Dietz, Emmet Doherty, Henry Thurston, Robert Taylor, Herbert Moore, Ramon Conover, Charles Allison and Charles Travis, for the keen interest they have taken in the mineral occurrences of this district, and the generous help they have given in locating them. Also the writer is especially indebted to Mr. Charles Travis for the time and services and use of his car which he has given and is still giving so freely for this exploration work. Through his warm friendship, keen interest and enthusiasm in the mineralogical history of Peekskill, a large amount of interesting minerals have been found and collected. The writer is frankly amazed at the great number and variety of minerals which have been found since June, 1932.

The Amateur Lapidary

Conducted by

J. H. HOWARD*

504 Crescent Ave., Greenville, S. C.

Amateur and professional lapidaries are cordially invited to submit contributions and so make this department of interest to all.

*Author of—*The Working of Semi-Precious Stones.* A practical guide-book written in untechnical language for those who desire to cut and polish semi-precious stones.

OPAL POLISHING

The working of opal is not different in general from the similar operations for agate, jasper, etc., except that the opal is softer and is therefore easier to cut and polish.

Nearly all the opal with which we work is from either Australia or Western United States. The Australian opal may be sawed, cut and polished exactly as the similar operations for harder stones but at the conclusion of the tin oxide polishing operation there may be visible scratches and the stone will certainly lack the velvety finish that is wanted. This desired polish may be given it by a final operation with soft rouge paste on either felt or buckskin or sheepskin lap.

The same note as to finishing applies to the Western U. S. opal but this material presents more serious problems in the earlier stages of work. The writer does not know just why this opal behaves as it does. It is very subject to cracking in all operations including sawing and must be handled carefully. We have heard the theory that the material is full of minute cracks. These cracks are the result of strain set up as the material hardened and the strain still exists. The cracks are often invisible to the naked eye and even with a ten power glass may not be seen. The heat generated by friction with the saw or the carbo wheel or the felt lap increases the strain. The trouble is further intensified by the application of the cold water generally used on the wheels.

Whatever the reason, the fact remains that many stones, beautiful in the rough

and apparently perfect and unflawed, will during cutting, develop cracks. Sometimes they will become filled with feathery cracks and sometimes they will break in two. We know of no remedy. However, there are some precautions that may be taken and that will help. Some of the lapidaries largely overcome this trouble by using very hot water on their wheels. Use as high temperature as the hands can bear. The stones should be warmed gradually and cooled the same way. Do not try to cut too fast. The extra heat that is generated by too great pressure on the stone will often cause the cracking. To summarize, the precautions are, patience and care to not too rapidly change the temperature of the stone.

Dr. Dake calls our attention to another point that mav give trouble to a beginner and in fact to a professional. The color in opal is usually in layers. This structure is often visible. The Australian opal should be cut with the veins of color parallel to the crown of the gem. With the U. S. opals, however, the crown of the stone should often, but not always, be at right angles to the vein of color. We do not know of any way to determine which method is best in any particular case but only suggest a careful examination of the stone before cutting is begun, so that orientation may be as correct as possible.

Messrs. Parker and Geisler, instructors at Shortridge High School, Indianapolis, have discovered that titanium oxide is a good polishing medium for cabochon cut stones. We have checked this report and find it correct. It seems most effective when used on a hard felt lap. We have not experimented enough with this material to enable us to say positively if it is better than tin oxide or not as good. But it is well worth trying.

* * *

Mr. Arthur Knapp of Philadelphia has reported some very valuable findings. One is that linoleum of the "battleship" type, or linotile, when used with tin oxide is an excellent polishing lap for cabochons. The other and more important discovery is that "Masonite Prestwood" with tin oxide will put a perfect polish on flat work. It works without scratching in many circumstances where the tin lap might tend to scratch. It is slower than a tin lap and on small facets it has a tendency to round the edges, but it is excellent for polishing large surfaces such as the tables of large brilliants or step cut stones or the flat bases of cabochons.

We thank all these gentlemen for writing us. It is only by such co-operation that this page can be made of value and interest

Oregon Agate and Mineral Society

A new club recently formed and which shows promise of developing into a mighty fine organization is the Oregon Agate and Mineral Society of Portland, Ore. That its success is already assured we need only to say its president is Dr. H. C. Dake.

The purpose of the new club is to stimulate public interest in the vast mineral resources of the State, to encourage the study of mineralogy in the public schools, and to promote mineral collecting. As Oregon is noted for its beautiful agates of which there is an amazing large number of collectors within its borders, it was decided to incorporate the word "agate" in the official name.

Meetings will be held twice a month, on the first and third Fridays, at the Chamber of Commerce Building. Dues are to be nominal, about $1 a year.

The first meeting was held on Friday, January 20th, 1933, with 48 keenly interested collectors being present. An exceptionally fine display of agates and a talk on the "Genesis of Quartz and Agates" by Dr. E. W. Lazell were the main features. The officers elected at this meeting for the ensuing year were:

President, Dr. H. C. Dake; vice-president, Dr. E. W. Lazell; Secretary and treasurer, Mrs. Mabelle Gordon.

Field Trip Committee—F. S. Young, Dwight Hill, Victor Kayser, Thos. Carney, R. L. Lakin.

The second meeting was held on Friday, February 3rd, when in spite of adverse weather conditions and an error of the press in the mention of the date, 75 members and friends were present.

OPAL GLOSSARY

——*By*——

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Introduction

For the most part, this glossary consists of the varieties of opal. A few terms have been added because of their special association with the winning of opal in the different fields, because of their historical significance, or because of their use in articles on opal appearing in this Issue.

It hardly seems necessary that there should be as many terms for the varieties of a mineral as there are in the case of the opal. The fine points which serve to distinguish one variety from another hardly seem adequate to give the specimen a new name, other than that of a descriptive term such as "Gold Opal", "Moss Opal", etc. Such terms would then merely refer to an opal having certain characteristics. Consider the case of the "Gold Opal". This would not be a different species of opal, but an opal "showing yellow light over large areas" having the same composition and properties as the opal of which it is considered a variety. Nevertheless, the following terms are widely used by mineralogists and opal dealers.

Acknowledgment

This glossary is compiled from the descriptions and definitions used by over twenty-five authors, to whom I am indebted for the use of their material. Chief among these are Miss Irene Aitkens, Edward S. Dana, Albert H. Fay, Gilbert Hart, George Frederick Kunz, and Edward Henry Kraus. The generous assistance of Mr. Zodac, Editor of ROCKS AND MINERALS, in making this list as inclusive as it is, is also gratefully acknowledged.

Glossary

1. Agate Opal. Common opal banded in alternate layers of opal and agate (chalcedony). Agate-like in structure, but consisting of opal in different shades of color. Also called Opal Agate and Opalized Agate. (17, 73, 89, 116)*
2. Agatized Wood. See Opalized Wood.
3. Alumocalcite. A variety of opal with alumina and lime as impurities. (89, 203).
4. Amber Opal. Brownish-yellow variety stained by iron oxide. (116).
5. Bandstone. Miners' term used at White Cliffs, New South Wales, for flat bands of opal-impregnated silica harder than the adjoining strata, often containing opalized shells, and sometimes belemnites, and usually having cracks which have been filled with opal. The workable opal-bearing seams occur either just above or below the bandstone, generally below. (89, 178).
6. Bergmehl. Diatomaceous Earth. (166).
7. Black Opal. Dark green, blue, or black variety of precious opal. This beautiful stone changes from a glowing green to gold or pale violet, then to crimson or blue according to the direction of the light. Opal in a dark matrix or showing vivid dark colors is also known as black opal. It occurs only, as far as is known, at Lightning Ridge, New South Wales. (17, 116, 159, 216).
8. Blue Opal. A synonym for lazulite, which is a hydrous iron, aluminum, magnesium phosphate. (73, 89).
9. Boulder Opal. Term used by Queensland miners for nodules of siliceous ironstone of concretionary origin containing precious opal and occurring in the opal-bearing sandstones and clay at all depths. (125).

*The numbers in parentheses refer to the author's "Opal Bibliography", this Issue, pp. 51-60.

10. Cacholong. A milky-white, opaque (or feebly translucent), porcelain-like variety of common opal. It is very porous and adheres to the tongue. It contains a little alumina and has a luster somewhat similar to that of mother-of-pearl. It may be bluish-white, pale yellow or reddish. Cacholong is said to have been named from the Cach river in Bokhara, but the word is probably of Tartar origin. (17, 73, 89, 116, 188, 201).
11. Cacholong Opal. See Cacholong.
12. Cat's-Eye Opal. The rarest form of Harlequin exhibiting a chatoyant line over the center of the dome similar to the cat's eye and usually of a bright green color. (57).
13. Ceylon Opal. A variety of feldspar: moonstone. (116).
14. Ceyssatite. Diatomaceous Earth. (166).
15. Chloropal. (1) Green opal from Silesia. (2) A green, opal-like, hydrous silicate of iron. (89, 116).
16. Common Opal. Translucent to opaque, multicolored opal not exhibiting a play of colors. (116, 132).
17. Desmid Earth. Diatomaceous Earth. (166).
18. Diatomaceous Earth. See Tripolite.
19. Diatomite. See Tripolite.
20. Earthy Tripolite. See Tripolite.
21. Electro-silicon. See Infusorial Earth.
22. **Enchabochon.** Stones exhibiting color combinations (flash and transparence being of minor esteem) instead of being cut in facets are not infrequently polished in their natural shape—**enchacochon**—or "tallow cut". The irregularities of formation, such as pearl blisters, which are very frequently used, impart not a little to the barbaric richness of the ornaments in which they occur. Most opals are cut in this manner although some are faceted. (125).
23. Eye-stone. See **Ophthalmios.**
24. "Filter-cel". Trade name of Diatomaceous Earth. (166).
25. Fiorite. Siliceous Sinter. Deposited from the siliceous waters of hot springs. Includes translucent to opaque, grayish or brownish incrustations, porous to firm in texture; sometimes fibrous-like or filamentous, and, when so, pearly in luster (then called Pearl-sinter). Fiorite is named from Mt. Santa Fiora in Tuscany. (73, 89).
26. Fire Opal. Yellow to red, translucent to transparent variety of precious opal having a fiery play of colors, somewhat irised on turning. (73, 132).
27. "Flame Queen". The most unique opal produced at Lightning Ridge, Australia, famous for its architecture. It resembles a fried egg, the yoke standing up a quarter of an inch above the white, the only difference being the colors, the centerpiece in the stone being a dark red bronze surrounded by a beautiful green border. This stone was sold by Phillips and Bradley for about $460 and later sold to Mr. Cupples of Brisbane for $2,500. (181).
28. Flash Fire. See Flash Opal.
29. Flash Opal. A precious opal in which the color shows as a single flash or in a very large pattern. The flash opal is often very beautiful especially when of the true ruby or pigeon's blood color. As a rule, however, it shows a green or red flash according to the angle at which it is held. (178).
30. Float-stone. A variety of opal that floats on water, found in light spongy concretionary or tuberous masses, sometimes cavernous; rough in structure. (73, 89).
31. Forcherite. Orange-yellow opal, the color being due to orpiment. (116).
32. Fossil Flour. See Infusorial Earth.
33. Fossil Pineapple. It is notable that opal sometimes replaces shells and even reptilian bones, and curious pseudomorphs known as "Pineapple Opal" or "Fossil Pineapple" show the opal in the form of aggregated crystals, perhaps of gypsum, gaylussite, or glauberite rosettes. (116, 216).
34. Frost-Stone. In 1912 chalcedony containing inclusions of white opal was discovered about 30 miles west of Barstow, California. This polished beautifully and was

put on the market under the name of "frost-stone" and met with a ready sale. (153).

35. Geyserite. Variety of common opal. Siliceous sinter or hydrated form of opaline silica deposited from hot waters around geysers or hot springs in various parts of the world. It appears white or grayish; in granular, porous, stalactitic, filamentous, cauliflower-like forms; also, compact-massive and scaly-massive; often of great beauty. See also Pealite. (73, 89, 116, 150).
36. Girasol. Blue, white, translucent variety of precious opal exhibiting a red play of colors. Girasol is also used to describe a variety of corundum and feldspar: moonstone. (17, 89, 116).
37. Girasol Opal. A fire-opal. See also Girasol. (116).
38. Gold Opal. Opal, showing yellow light over large areas. (116).
39. Harlequin. The pattern of an opal is an important factor in its value, especially in the case of this variety of precious opal, when the color is in small squares or checkers. Small angular patches of brilliant and variegated colors which change their positions and character as the stone is moved made the Harlequin the most beautiful as well as the most uncommon of the opals. When the squares of color are regular and show as distinct checkers of red, yellow, and green, this class of opal is truly magnificent. Seldom, however, are two colors shown at the same time, one being much more pronounced than the other. Also known as the Oriental Opal. (57, 89, 125, 178).
40. Harlequin Opal. In the variety known to jewelers as "Harlequin Opal" the rainbow-like tints are flashed forth from small angular surfaces, forming a polychromatic mosaic. See also Harlequin. (188).
41. Hyaline Opal. See Hyalite.
42. Hyalite. Common Opal, when pure, is transparent and colorless, as is well seen in the variety which, from its vitreous appearance, was called by A. G. Werner, Hyalite (from Greek word meaning glass), or popularly, "Muller's Glass", a name said to have been taken from its discoverer. This pellucid opaline silica occurs as an incrustation in small globules or with a botryoidal surface and is by no means a common mineral. Specimens breaking with an apparent starch-like fracture have been found in Lake county, California, by Mr. H. H. Meyer. Hyalite dissolves less readily in caustic alkalies than any other variety. Only rarely does hyalite show the fire that makes it desirable as a gem. It is best described as looking like drops of melted glass. (73, 100, 132, 134, 188).
43. Hydrophane. A cloudy, white, dehydrated variety of common opal. As explained by G. F. Herbert Smith, the cracks in certain opals were not filled up and therefore contain air. Such stones appear opaque and devoid of opalescence until plunged into water. They are consequently known as Hydrophane (from Greek words meaning water and to make appear). Owing to the effect of total refraction, light was stopped on the hither side of the cracks before they were filled with water, which is not very inferior to opal in refractivity. It is surprising how much water these stones will absorb. (131, 201).
44. Infusorial Earth. Diatomaceous Earth. Tripolite. An earthy substance or soft rock composed of the siliceous skeletons of small aquatic plants called diatoms. (A former and common, but incorrect usage. Properly Diatomaceous Earth.) Useful as an absorbent of nitro-glycerin. Called also Infusorial Silica and Fossil Flour, and in special forms Rottenstone and Electro-silicon; Kieselguhr. See also Tripolite. (89).
45. Infusorial Silica. See Infusorial Earth.
46. Isopyre. A very impure opal. (116).
47. Jasper Opal. A greasy, opaque, yellow, yellow brown, reddish-brown, to red variety of common opal, with a resinous luster, resembling jasper. The color is due

to impurities, principally of iron oxides. (73, 89, 132).

48. Jaspopal. See Jasper Opal.
49. Kieselguhr. Kieselguhr was used in the packing of dynamite in the latter part of the 19th Century. This practice was gradually discontinued with the invention of Kieselguhr Dynamite, very little being used since the 1880's. Two reasons why Kieselguhr as an absorbent was diadvantageous are that water easily displaces the nitro-glycerin, and 25 per cent. of the weight is inert material which takes no part in the explosion, but absorbs heat and decreases the effect of the explosive. One of the early reasons for efforts to find other suitable absorbents was the desire to evade Nobel's patents. This very practical reason, more than the increased efficiency of "active dopes", probably caused substitutions to be made at an carly date. See also Infusorial Earth. (Kitts, J. W., personal correspondence.)
50. **Lapis mutabilis.** See **Oculus Mundi.**
51. Lechoso. (Mex.) Milky variety of opal. (89).
52. Lechosos Opal. Variety of precious opal. Milky, with flashes of deep green and carmine. (17, 116).
53. Lithoxyle. Wood silicified by opal showing woody structure. See also Opalized Wood. (116).
54. Liver Opal. Menilite. Brown or dull gray, opaque, banded, or concretionary variety of common opal. (73, 131).
55. Magic Stone. A white, opaque variety of Hydrophane, in rounded lumps, with a chalky or glazed coating has been found in Colorado. Its power to absorb liquid is quite remarkable. When water is allowed to slowly drop on it, it first becomes white and chalky and finally transparent. This is so striking that the finder proposed the name "Magic Stone" for it, and suggested its use in rings, lockets, charms, etc., to conceal photographs, hair, or other objects which the wearer wishes to reveal only when his caprice dictates. Analyses have shown that it absorbs more than an equal volume of water. The specific gravity of four specimens averaged 2.1. (137).
56. Menilite. Liver Opal. Found in Tertiary shells at Menilmontant, near Paris, France. See also Liver Opal. (188).
57. Milk Opal. Translucent, milk-white, yellowish, greenish, or bluish variety of common opal. (116).
58. Molucca. Diatomaceous Earth. (166).
59. Moss Opal. Milky variety of common opal with black dendritic inclusions of manganese oxide which resemble moss. (116, 131).
60. Mother-of-Opal. Rock matrix containing minute disseminated specks of precious opal. (116).
61. Muller's Glass. See Hyalite.
62. "Mullock". In mining opal in Australia the miner digs four feet below the layer containing the opal and then tunnels along beneath it, leaving the opal sheet as a roof and when sufficient space has been provided the "Mullock" is hauled to the surface by means of a crude windlass, after which the opal is removed from the clay-incrusted roof with knives or other convenient tools. (159).
63. Niggerhead. Oval or spherical masses of more or less opal-impregnated, fine-grained silica. They frequently weigh from 1 lb. to 1 cwt., and usually contain a center of opalized wood, or opal of good color in cracks caused by contraction may be found. (178).
64. Nobbies. Local name for gem opals coated with "opal dirt", (Australia). (152).
65. Noble Opal. Precious Opal. The word "noble" is used in mineralogy to express superiority or purity, e. g., noble opal, noble tourmaline, noble serpentine, etc. (89, 116).
66. **Oculus Beli.** See **Oculus Mundi.**
67. **Oculus Mundi.** A specimen of Hydrophane brought from China centuries ago was called the **Oculus Mundi,** or World's Eye. It was similar to the **Lapis Mutabilis,** (Tavernier's Snake-Stone), which, when wet, became entirely transparent except for a central nucleus, possibly a core of chalcedony,

that remained white. If the central core was black, evidently oxide of manganese, the stone was called **Oculus Beli.** (134).

68. Opal. Used as a prefix or suffix indicating (1) an opal of the color or type mentioned, (2) an admixture of opal with some other gem, or (3) an opalescent variety of some other gem.
An amorphous hydrous silicate, characterized by its iridescent refraction of light. It occurs in many colors and varieties, being considered a gem when displaying a prismatic play of color. See also Common Opal and Precious Opal. (116, 173).
69. Opal Agate. See Agate Opal.
70. Opal Dirt. An opal-bearing layer of soft material like clay, or clayey sand, usually less than three feet in thickness, underlying the sandstone cap, (Australia). (124, 152).
71. Opalescent Chrysolite. Given by Gilbert Hart as an opalescent variety of Chrysoberyl. While Chrysoberyl is sometimes opalescent, the variety Chrysolite is not given in mineralogical texts. The latter term is reserved for Olivine or Peridot. (116).
72. Opalescent Sapphire. Opalescent variety of Corundum. (116).
73. Opaline. (1) Opal Matrix. (2) Pale blue to bluish-white opalescent Corundum. (116).
74. Opaline Feldspar. A variety of labradorite. (116).
75. Opalized Agate. See Agate Opal.
76. Opalized Wood. Wood Opal. Silicified Wood. Xylopal. A variety of common opal in which wood has been petrified by opaline material retaining its woody structure. In California the ancient gold-bearing gravels overlaid by a capping of lava or tufa frequently contain trunks and branches of trees that have been permeated by siliceous waters and thus fossilized. In some cases the replacing material is opal silica, and very interesting grades in the process of which can be seen even in parts of the same specimen. See also Wood. (89, 132, 135).
77. Opal Jasper. See Jasper Opal.
78. Opal Matrix. (1) Opal in its matrix. (2) Variety of Precious Opal. In many black opals the opalescent material occurs in far too tiny pieces to be cut separately, and the whole iron-stained matrix is cut and polished and sold under the name Opal Matrix. (17, 148).
79. **Opalo.** (Sp.) Opal; **Opalo de fuego,** Fire Opal; **Opalo nobles,** Precious Opal. (17, 201).
80. "Opal of Nonius." Pliny writes as follows: "There exists today a gem of this kind (the **Opalus**), on account of which the senator Nonius was proscribed by Antony. Seeking safely in flight, he took with him, of all his possessions, this ring alone, which, it is certain, was valued at 2,000,000 sesterces ($80,000)." Kunz says that this stone would be the "Great Historic Opal" if we could be assured that the stone mentioned by Pliny was an opal. See also **Opalus.** (148).
81. Opal Onyx. Alternate layers of common and precious opal. (116).
82. **Opalus.** Also spelled **Opallus.** The **Opalus** was mentioned by Pliny as the "Opal of Nonius", but Kunz doubts if this stone could have been an opal in spite of the vivid and accurate description which seems to identify it with the opal of today. Pliny said that this stone could be imitated better than any other, and it is known that the opal is one of the most difficult stones to duplicate. Furthermore, no opal is known to have come from the localities known to Pliny and the Hungarian fields were not then open. (17, 148).
83. **Ophal.** At the time of Queen Elizabeth, opal was written **"Ophal",** derived from **ophthalmos,** the eye. (148).
84. **Ophthalmios.** The Edda tells of a sacred stone called the Yarkastein which the clever smith Volondr (the Scandanavian Vulcan) formed from the eyes of children. Grimm conjectures that this name designates a round, milk-white opal. Certainly the opal was often called **ophthalmios,** or Eyestone, in the Middle Ages, and it was a common idea that the image of a boy or girl could be

seen in the pupil of the eye. (148).

85. **Ophthalmus Lapis.** A certain imperial gem **(Orphanus)** was regarded as **sui generis,** and Albertus had just described the **Ophthalmus Lapis,** a name frequently bestowed upon the opal in medieval times, reciting the virtues usually ascribed to the opal for the cure of diseases of the eye and the magic power of the stone to render its wearer invisible, wherefore it was designated as **patronus furum,** patron of thieves. (148).

86. **Optalio.** Batman writes as follows: "**Optalio,** called **Oppalus** also, and is a stone distinguished with colors of divers precious stones, as **Isid.** saith. . . . This stone breedeth onely in **Inde** and is deemed to have as many virtues, as hiewes and colours. Of this **Optallius** it is said in Lapidario, that this **Optallius** keepeth and saveth his eyen that beareth it, cleere and sharp and without griefe, and dimmeth other men's eyen that be about, with a maner clowde, and smiteth them with a maner blindnesse, that is called **Amentia,** so that they may not see neither take heede what is done before their eyen. Therefore, it is said that it is the most sure patron of theeves." (148).

87. Oriental Opal. Often an opal mined in the United States or Europe will bring a higher price if it is imported back from the Orient. Such stones are known as Oriental Opals. See also Harlequin. (Thomas, J., personal communication.)

88. **Orphanus.** Albertus Magnus describes under the name **Orphanus** a stone which was set in the imperial crown of the Holy Roman Empire. This gem is believed to have been a splendid opal and Albert described it as follows: "The **Orphanus** is a stone which is in the crown of the Roman Empire and none like it has ever been seen; for this very reason it is called **Orphanus.** It is of a subtle vinous tinge, and its hue is as though pure white snow flashed and sparkled with the color of bright ruddy wine, and was overcome by this radiance. It is a translucent stone, and there is a tradition that formerly it shown in the night-time; but now, in our age, it does not sparkle in the dark. It is said to guard the regal honor." See also **Ophthalmus Lapis.** (148).

89. Paederos. A greek designation for Cupid. Applicable to all rosy stones. The term used by Romans for opal. (17).

90. "Pandora Opal." This opal is recently reported to have been found at Lightning Ridge, New South Wales. It is a beautiful stone, weighing 790 carats, but when cut and polished there will be about 590 carats. For its size it is the best big stone Australia has yet produced. As a rule Australian big stones are not gems, but the "Pandora" is a good quality opal, the blending of the colors being wonderful. On one end of the stone the opal represents a beautiful fan or peacock's tail; on the other parts of the stone are different opals, all harmonizing in their wonderful colors. The value of the "Pandora" rests with the buyer and seller, but it will surely run well into four figures, in English pounds, and it will be the highest price ever paid for a single stone on the Ridge. (17, 181).

91. "Patron of Thieves." See **Ophthalmus Lapis** and **Optalio.**

92. **Patronus furum.** See **Ophthalmus Lapis.**

93. Pealite. Near the cone of the Giant Geyser, on the upper Geyser Basin of Fire Hole River, Dr. Albert C. Peale, assistant geologist to Dr. Hayden's survey of the Yellowstone National Park in 1872, found near the base of the crater, apparently running through in nearly horizontal layers, a peculiar variety of geyserite, similar in some respects to the opal, which was named "Pealite" after the discoverer. It occurs in irregular tablets sometimes with scalloped surfaces. It is claimed that the position taken by this mineral, between quartz and opal, according to its chemical and physical characteristics, and the variance which it shows from oth-

er geyserites and kieselsinter, justify its distinction from them by a specific name. Although some specimens closely resemble semi-opal, it seems improbable that opal could be formed in the same way. They might well be used for small, odd ornaments, mounted as they are found, without any cutting. (134).

94. Pearlite. (1) Geyserite variety of Opal. (2) Spherulitic obsidian. Called also Perlite and Pearlstone. Pearlite is also a eutecoid of cementite and crystallized iron formed by slow cooling of molten steel. (89, 116).
95. Pearl Opal. Same as Cacholong, an opaque, bluish-white, porcelain white, pale yellow, or reddish variety of opal. (89).
96. Pearl-sinter. See Fiorite.
97. Petrified Wood. Wood replaced by silica, usually quartz, but also chalcedony and opal. See also Wood. (116).
98. Pineapple Opal. See Fossil Pineapple.
99. Pin Fire Opal. Opal in which there are very small areas of individual colors. As mentioned before, the pattern of a gem is an important factor in its value and this is especially true of the Pin Fire Opal when the grain, if it may be so called, is very small. (116, 178).
100. Pin Point Opal. As mentioned under Pin Fire Opal, gems are commercially described as having certain "pattern". In some the colors are in patches, layers, or stripes, or of one color only. Sometimes they are so minute that the stone is known as the Pin Point Opal. (183).
101. **Pintas.** The opal-impregnated areas of Mexico are now traced by surface indications called **pintas.** These become visible through the weathering of the rock and consist for the most part of a white siliceous sinter filling cavities in the rhyolite. **Pintas** are infallible indications of opal, but the quality and quantity can only be proved by development. (160).
102. Pipe Opal. Term applied in Australia to any long, narrow cavity filled by opal; also opalized belemnites, long narrow cigar-shaped fossils. (89, 116).
103. Pitch Opal. A brown inferior quality of common opal with a pitchy luster. (89, 116).
104. Polirschiefer. Diatomaceous Earth. (166).
105. "Potch." Young, false, or dead opal. Miners' term for an opal which may be colorful, but not alive. (159).
106. Prase Opal. Translucent, apple-green variety of common opal. (17, 116).
107. Precious Opal. Precious Opal includes only those stones which exhibit a brilliant play of delicate colors. Also called Noble Opal. Precious Opal with the lighter colors is called White Opal and the dark gray and blue opals are designated as Black Opals. Because of the play of colors exhibited by this gem it is cut **enchabochon** in order best to display this phenomenon. (131, 132, 178).
108. Quinzite. Rose Opal, found at Quincy, near Mehun-sur-Yevre, in France. See also Rose Opal. (188).
109. Radiolarian Earth. Diatomaceous Earth. (166).
110. Radio Opal. Opal in which the smoky brown color is due to organic inclusions. (116).
111. Randanite. Diatomaceous Earth. (166).
112. Resin Opal. Wax-, honey-, to ochre-yellow variety of common opal with a resinous luster. (73).
113. "Root of Opal." The "root of opal" consists of the mineral disseminated through the matrix. See also Mother-of-Opal and Opal Matrix. (188).
114. Rose Opal. Quinzite. A beautiful pink variety of common opal colored with organic matter. (131, 188).
115. Rubolite. A red opal from Texas. (116).
116. "Sandstone" Opal. One of the miners' varieties of opal found in the rough, (Queensland). (125).
117. Schaumopal. A porous variety from the Virunga district, German East Africa. (73).
118. "Schnide." Queensland term. More than 90 per cent. of all the opal obtained is valueless, being com-

mon opal, "Schnide" of the miners, or of the glassy bluish variety containing little or no color. (125).

119. Semi-opal. (1) Common opal as distinguished from precious and fire opal. (2) A dull opaque form of opal with an imperfectly conchoidal fracture, colorless to highly colored. On the surface of a locality in San Bernardino county, California, some 25 miles northwest of Barstow, are found large deposits of what is called "Semi-opal", a stone which resembles the genuine opal, but has not its beauty. (73, 89, 116, 135, 188).
120. Siliceous Sinter. See Fiorite and Geyserite.
121. Siliceous Tuff. Siliceous Sinter with a very loose texture.
122. Silicified Wood. See Wood and Opalized Wood.
123. "Sil-o-cel." Trade name of Diatomaceous Earth. (166).
124. Sinopal. Spelled also Sinople. (1) Aventurine Quartz. (2) Variety of Sagenite. (3) A ferruginous quartz from Hungary. (4) A ferruginous clay from which the pigment sinopia is prepared. Called also Sinoper and Sinopite. (89, 116).
125. Smoky Opal. Smoky brown variety of opal. (116).
126. Sobrisky Opal. Opal from Death Valley, California. (116).
127. Sun Opal. Opal, variety of Fire Opal. (116).
128. Tabasher. Spelled also Tabasheer. Variety of common opal. Amorphous opal-like silica deposited in the joints of bamboo and used in native jewelry in the Orient. It becomes transparent in water. (17, 116, 131).
129. "Tallow Cut." See **Enchabochon.**
130. Tavenier's Snake-stone. **Lapis Mutabilis.** See **Oculus Mundi.**
131. Tellurine. Diatomaceous Earth. (166).
132. "Trio-o-lite." Trade name of Diatomaceous Earth. (166).
133. Tripolite. Diatomaceous, or Infusorial Earth. An opal silica composed of the siliceous shells of diatoms (hence called Diatomite), radiolaria, and other microscopic species, and occurring in extensive deposits. It is porous, earthy, gritty, chalklike, and is light in weight. The term Tripolite is sometimes applied to the decomposition product of siliceous limestone. Includes Earthy Tripolite (the Infusorial Earth above), a very fine-grained earth often looking like earthy chalk or a clay, but is harsh to the feel. (73, 89, 132).
134. **Upala.** Sanskrit word for opal, meaning "a precious stone". (29).
135. Vermilion Opal. Milky opal impregnated with red cinnabar. (116).
136. Vermilite. Vermilion Opal. (116).
137. "Water Dogs". Small, round boulders. intensely hard, covering the outlying hills and tablelands of Queensland, being the covering of debris consisting of rounded or ellipsoidal boulders, from 6 to 12 inches in diameter and slag-like masses, flint-like, which ring like metal to the hammer, and break with a conchoidal fracture. These boulders belong to the same formation in which the opal occurs beneath the surface: Rolling Downs formation, lower Cretaceous age. (125).
138. Water Opal. (1) Moonstone variety of feldspar. (2) Hyalite. (116).
139. Water Stone. Hyalite. (116).
140. Wax Opal. An early name for yellow opal with a waxy luster. (89).
141. White Opal. Precious opal having lighter colors. (132).
142. White Peat. Diatomaceous Earth. (166).
143. Wood. Agatized, opalized, petrified, silicified wood: a material composed of opal or chalcedony (agate) and formed by the replacement of wood by silica. The replacement of the woody matter by the silica takes place in such a way that the original form and structure of the wood is preserved. (89).
144. Wood Opal. See Opalized Wood.
145. World's Eye. See Oculus Mundi.
146. Xylopal. See Opalized Wood.
147. Yarkastein. See **Ophthalmios.**
148. Zeasite. (1) Wood Opal. (2) An old name for a variety of Fire Opal. (89).

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OPAL BIBLIOGRAPHY

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Introduction

The following list of references on opal is composed largely of works which have been used liberally in "Opal Glossary" and "The Story of Opal" by the writer and appearing in this issue. Other important references have been added to make it more complete, but it is not claimed that this list includes all the references on the subject. In "Opal Glossary" specific mention of this list has been made by adjoining numerals, but in "The Story of Opal" this has not been done as the material was assembled from so many sources that it would only be confusing to try to indicate the immediate source of each item. In many cases the same fact has been related by so many authors, that it is difficult to know where it originally appeared. Furthermore, where material on opals is repeatedly given in successive series of a publication, only those which the writer has actually employed are cited. This applies to the "Mineral Resources of the United States," "The Encyclopaedia Britannica," Publication of the California State Mining Bureau, etc.

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